Contents

Impact, Vol. VII, No. 4, December 1956

AUTOMATION—VERBAL FICTION, PSYCHOLOGICAL REALITY
by the EARL OF HALSBURY 179

Automation is a material reality. It is also a psychological reality. The two realities do not necessarily correspond. As a material reality automation is a source of wealth. As a psychological reality it is a source of fear. This essay, which studies closely both realities, helps to show how they can coalesce, for such is the function of the social sciences in their application. They have few functions of comparable importance in the contemporary world.

THE IDENTITY OF THE PERSON—ITS IMPORTANCE FOR THE INDIVIDUAL AND FOR SOCIETY
by CHARLES SANNIÉ 202

The identity of the person is of great importance from the social, legal and purely human points of view. Every month thousands of people disappear leaving no trace—and many of them reappear under a false identity. Innumerable frauds are perpetrated under cover of false identities. Sometimes an innocent is found guilty on evidence which is based on unreliable criteria of identity. It even happens that children are substituted in maternity clinics for lack of reliable criteria of identity. In fact, the present methods of ascertaining the identity of the person are unreliable and even misleading. The author studies these methods and considers how they could be improved so as to give better guarantees to the individual as well as to society.

LEAF PROTEIN—FOOD OF THE FUTURE
by RALPH WHITLOCK 225

Side by side with the encouragement of more efficient agriculture on land already under cultivation and with the development of new marginal areas, goes investigation into new sources of food supply. One such source which has recently made its appearance is from the extraction of leaf protein. This protein, when refined, is easily digestible by human beings; in its cruder form it is an ideal animal food. The extraction of leaf protein, if suitably developed, would prove a powerful factor in solving the problem of the world's food supply.

BOOKS AND PUBLICATIONS
The Father of Scientific Detection
by CHARLES SANNIÉ 234

The Director of the Paris Identité judiciaire *writes a brief essay on his famous predecessor apropos a biography of Alphonse Bertillon by H. T. F. Rhodes.*

CONTENTS OF PRECEDING ISSUES

Vol. VI, No. 3, September 1955

The Duality of Science: Knowledge and Action, by Pierre AUGER.
Population Genetics and the Study of Man, by Jean SUTTER.
National Research Councils and Science Policy, by Werner MOLLER.
The Career of the Research Worker, by Y. de HEMPTINNE.

Vol. VI, No. 4, December 1955

Warning and Promise of Experimental Embryology, by H. V. BRONDSTED.
Design and Chance in Discovery and Invention, by René TATON.
Pages from the Past: T. H. Huxley—The Statesman of Nineteenth-Century Science.

Vol. VII, No. 1, March 1956

Science and the Changing Face of Industry—The Social Phase, by Alexander KING.
Biology and Medicine at the Geneva Conference (8-20 August 1955), by Jean COURSAGET.

Vol. VII, No. 2, June 1956

Medical and Social Problems of Aging, by R. E. TUNBRIDGE.
The Impact of Viruses on Society, by F. C. BAWDEN.
Energy Production at the Geneva Conference (8-20 August 1955), by P. TARANGER.

Vol. VII, No. 3, September 1956

Ten Years of Science at Unesco, by Marcel FLORKIN.
The Social Character of Technology, by Tom BURNS.
Fifty Years of Medical Research, by A. C. ALLISON.

AUTOMATION—VERBAL FICTION, PSYCHOLOGICAL REALITY

by

the EARL OF HALSBURY

Lord Halsbury, F.R.I.C., F.Inst.P., a research chemist by training, has been Managing Director of the National Research Development Corporation since 1949. He was a member of the Advisory Council of the Committee of the Privy Council for Scientific and Industrial Research from 1949 to 1954, and is now a member of its Mechanical Engineering Research Board. He is also a Deputy Chairman of the Parliamentary and Scientific Committee of the United Kingdom, Chairman of the National Institute of Industrial Psychology, Vice-President of the Institution of Production Engineers and of the Royal Institute of Philosophy, and a member of the Court of Governors of the Manchester College of Science and Technology.

'Automation' is not a technological term, though it started as the nickname for a technological problem of much narrower scope than its current use would lead one to suppose. Its use, more frequently its abuse, pertains to journalism and sales promotion. Journalists for the most part seem unaware th.. they have, to all intents and purposes, coined it themselves. When they ask technologists what it means, the question ought to be referred back to them.

There is in fact considerable confusion involved in this matter. Journalists seem to think that there is a new technological process, called automation, to be compared in its novelty with nuclear energy generation or antibiotic manufacture, and that this new technique will result in automatic unmanned factories, the installation of which will cause widespread unemployment. Thus journalists have misled not only one another and the public, but trade unionists as well—some of whom have reacted by stating what they would do about it. These statements have been written up by the daily press as if a real situation were involved, and some current events (such as the strike at the Standard Motor Co.) have been interpreted in terms of workers' resistance to automation. The public has thereby been still further misinformed. The situation is rather like the growth of a rumour; no one can subsequently give a satisfactory account of how large numbers came to believe a story having no foundation in fact. Press and unions have in fact been stoking one another up till both have come to believe that what they are talking about corresponds to reality. Needless to say, the more responsible members of each group do not believe this.

WHAT IS MEANT BY AUTOMATION

Various attempts have been made at defining automation in general terms. These all exclude one or another of the activities which, by popular consent, are now called 'automative'. Consequently they are unsatisfactory.

I have suggested elsewhere that the only way of bringing order out of this chaos is to freeze the use of this word so as to cover every context in which it is now employed, and to extend it no further. Failing this, it will come to mean whatever the user has in his mind when he uses it, and by meaning everything in general will end by meaning nothing in particular.[1] If this proposal is accepted (and no one has so far disagreed with it), then we are left with four unrelated topics to discuss.

1. *Transfer Processing*. That is to say, linking fabrication operations, normally performed individually and in sequence, into a continuous process of an automatic character.
2. *Automatic Assembly*. This resembles transfer processing in definition, except that it relates to the assembly of many units rather than to the forming or fashioning of a single unit.
3. *Control Engineering*. This is concerned with the automatic control of self-regulating processes, and describes devices of which examples are the speed governors of steam engines, thermostats, autopilots and so on.
4. *Communication Engineering*. Only part of this subject is involved, namely that part which relates to data processing, accountancy and mathematical operations conducted with electronic digital computers, and the linkage of computers to physical or chemical processes.

These topics will be described in more detail below. For the present it will suffice to have enumerated them briefly, as above, in order to continue the process of definition and explanation for the removal of misunderstandings.

First of all, many processes employ more than one of the above techniques. Thus transfer processing involves a measure of automatic control, and automatic control may involve the use of a digital computer, parts of which may have been fabricated using methods of automatic assembly.

Secondly, it should be noted that the fourth item above includes the use of the word 'electronic' to describe a particular device, the computer. As automation is linked in the public mind with electronics, it ought to be explained that there is no necessary connexion between them. Transfer processing is in fact far more dependent upon pneumatics (the use of compressed air) than upon electronics. Automatic control employs both pneumatics and electronics when suitable opportunities for either present themselves. Communication engineering is, in its automative aspects, almost entirely electronic in character. Automatic assembly does not at present depend to any great extent on either type of technique.

Thirdly, from the sociological point of view, it is impossible to avoid

spurious distinctions arising from the foregoing. Thus if a milling cutter and a grinder, regarded as unit machines in sequence, are coupled by a transfer machine, the new unit process resulting is 'automation'. If, however, the grinding machine is rendered superfluous by high speed milling, the result is not automation. We have in fact no generic term for it, except 'advanced machine shop practice'.

Examining these four processes in search of a common feature which could be made the basis of a general definition, it seems that they possess one rather slender link in common, namely that they reintegrate processes, hitherto broken down into sub-divided tasks, by rendering the whole continuous. 'Re-unification in continuity' thus presents itself as a theme which could be the basis of a general definition, but it is too general to be of much use and would result in including old processes which no one has, as yet, classed as automative.

So far, this description runs parallel with that given in the report on automation sponsored by the Department of Scientific and Industrial Research,[1] except that the report couples transfer processing and automatic assembly together, and thus reduces the topics classifiable as 'automation' to three in number. There are, I think, some advantages in keeping them separate. The report, however, goes a great deal further by defining 'complete automation' as appropriate to cover the case of a completely automatic or 'push-button factory', the administration and works management being supposedly controlled by a computer. In fact, it goes a great deal too far if the definition implies that such a factory exists anywhere on earth. If one is to take cognizance of mere possibilities (in the sense that there is no law of nature excluding them) in framing definitions, then why not go to the limit and declare the factory self-repairing, thus eliminating the maintenance engineers as well as the works manager? One would then be well and truly embarked on the writing of science fiction!

One could dismiss public preoccupation with the subject by observing that 'automation', as here defined, is no more than an arbitrary selection of topics culled from the current phase of advance in a two-centuries-old field, that of mechanization. Why coin a special word for an arbitrary selection, implying that something unprecedented is taking place? This attitude is certainly tempting. It is one that many if not most engineers would like to adopt. On the other hand, there is often a measure of unconscious wisdom in a public attitude, even if overlaid with misunderstanding, and it may be advisable to take cognizance of it.

Technical advances may be of two kinds: steady cumulative advances on broad fronts, and concentrated advances on narrow fronts—salients as it were thrust out into the technological unknown. The topics selected here as

1. *Automation*, Department of Scientific and Industrial Research, HMSO, London, 1956.

automative are not in fact chosen entirely at random. They are just those branches of technology where interesting salients are at present being pushed out. They are the subject-matter of many technical textbooks now being written, though the word automation is not found in them. To some extent these branches abut—are contiguous. They may later join up into a major strategic advance, or they may not; it is too early to say.

In so far as their implications may be more far-reaching than one can foresee, there is a case for advanced consideration of them, if that is the public wish. In fact, it *is* the public wish. One may therefore accept rather than reject the word automation, but help the public to use it in a rational way. Be it remembered always, however, that automation deals with advances, not with novelties, and that it is but a sub-species of the familiar species 'mechanization'. No one of the four topics is new. Like the Bourgeois Gentilhomme who talked prose all his life without knowing it, many people have been subject to automation for many years and were content, until recently, to call it 'advancing productivity'.

THE TECHNICAL REALITY

Transfer Processing

Transfer processing is not generally concerned with the manufacture of capital goods, such as electric generators, or consumable goods, such as textiles. It applies more typically to the manufacture of consumer's durables —products such as automobiles, refrigerators, sewing machines, typewriters and so on. These commodities are assemblies of sub-assemblies which may in their turn consist of sub-assemblies. Ultimately we reach *parts*. A part is itself the product of a sequence of fabricating operations. Considering an automobile as typical, it is an assembly consisting of sub-assemblies such as the chassis, the engine, the transmission, the gear box, the body work, the upholstery and so on. The engine is itself made up of sub-assemblies— the engine proper, the carburettor, petrol pump, self-starter, etc. The engine proper is made of parts—the cylinder block, the crank shaft, connecting rods, pistons, valves, bearings, and other such units.

Each of these parts results from a sequence of machining operations. Taking the cylinder block as typical, the top and bottom must be milled or broached flat and parallel, the cylinders must be bored, valve guides drilled, seatings ground, various flat surfaces milled on the exterior of the engine to which auxiliary sub-assemblies will be bolted in due course, and a multiplicity of holes drilled, some of which must be tapped so that bolts may be inserted in them. Each of these operations is carried out by a special-purpose machine designed to do that one operation and no other. Some of these

machines perform multiple operations, such as boring six cylinders simultaneously. As the function of machines of this character is to remove material, the production engineer is concerned to keep the latter to a minimum by appropriate design of the material fed to the machine. The generic term for an input of this kind is a blank. It will generally take the form of a casting, a forging or a stamping—the result of some prior, relatively unprecise, operation of a large scale character.

With these preliminaries, consider the function of a machinist. His task is threefold: first, to feed the blank into the machine in correct register therewith, by forcing it to abut on some fixed framework called a jig; secondly, to supervise the performance of the machine; and thirdly, to remove the finished work, and to inspect its dimensional accuracy by means of a gauge, thereby ensuring that nothing but good work is passed forward to his successor in the sequence of machine operations.

If the blank is small, it may be possible to mechanize the input process by means of hopper or magazine feed, of which a familiar illustration can be furnished in terms of the belt or drum feed of bullets to a machine-gun. If the throughput is large, it may be possible to arrange that it starts in response to the completion of automatic feed, carries out its operations automatically, and switches off to discharge its output on completion of its task. In this way an operator may be able to keep an eye on several such machines, inspecting the output of each in turn, subject to a suitable sampling routine.

If the blank is large, such as a cylinder-block casting, this approach fails; though it should be possible, in principle at any rate, to make the output of one machine feed automatically into the input of the next. This is the essence of transfer machining, and the issue is not whether it can be done, but whether is can be made to pay. Cylinder blocks are large unwieldy objects; moving them about automatically and clamping them into register to within a thousandth of an inch entails a large heavy machine for the purpose. Moreover, in committing himself to a continuous sequence of operations of this character, the production engineer commits himself also to the strategic snag that the whole line of machines must stop if, for one reason or another, any one of them stops, breaks down or goes out of adjustment. Furthermore, the mechanization of the feed must be accompanied by mechanization of the inspection procedure, and arrangements for rejecting defective work. Failing this, expensive machining operations will be carried out on worthless products.

The capital cost of providing these complicated automatic operations in relation to the capital cost of the machine tools will be an important consideration in determining whether transfer pays or not; for the object of transfer is primarily to increase output, and not to eliminate labour, which is a secondary objective.

The first such transfer-line was installed at the works of the Morris Motor

Company in 1923. It was technically sound but economically unsound. The capital costs of machine tools in relation to their rate of output was not high enough to make the transfer installation a paying proposition.

The second attempt at a transfer-line was made some twenty years later by Fords in Detroit and was economically successful, the relative capital costs involved having in the meanwhile altered in favour of the transfer process. The engineers responsible nicknamed their problem 'automation', and the name stuck. (Various proposals for a general definition of automation have to be rejected on the ground that they exclude what Fords did in Detroit; a general definition of a word which excludes its historical origin would be inappropriate.)

There is nothing which renders machining operations more suitable for linkage by automatic transfer than other engineering operations. The body work of a car consists of parts called panels, and each of these is the product of a sequence of pressing operations carried out on sheet-metal blanks. Linkage of these by automatic sequences constitutes 'transfer-pressing', and the totality of similar operations may be called 'transfer processing', one of the four topics to which the name 'automation' may be given.

The terminal economics of all such processes—that is, the economics of carrying an idea through to its logical conclusion, 'going the whole hog' or whatever one may call it—is a rather sensitive function of throughput. A production engineer tends to tackle first the easy problems which cost least, together with the rewarding problems which pay a high dividend. Next he will tackle willy-nilly any subordinate problems whose solution is required to make a bigger or better success of the first group of solutions. There will remain, thirdly, a group of problems which are not of prime importance, and whose solution is neither particularly easy, nor notably remunerative. The cost of solving these is usually determined by the law of diminishing returns. At the point where they engage the production engineer's attention, he is liable to be distracted by something more important elsewhere. But this may be all to the good, for there are disadvantages in overdoing a process of this kind. It becomes inelastic as it becomes more complex, and the cost of hold-ups and breakdowns rises. In order that a whole line should not halt by reason of an adjustment required to one machine, it is necessary to arrange reserve stocks of work in progress at regular intervals down the line in such a way that the line can deliver into the reserve or buffer stock if there is a halt ahead of it, or take its input from the buffer stock if there is a halt behind it. It may be convenient to make these points identical with some process requiring manual operation, the mechanization of which would be tricky and difficult.

Matching all these necessities and opportunities requires detailed ingenuity by production engineers. They are not engaged in an intellectual game called 'going the whole hog' or 'eliminating the last man'. They are concerned with

minimizing costs. As to 'eliminating the last man', suppose the manual operators have indeed been reduced to one and one alone. Replacing him would require a machine and the services of a maintenance engineer. A special purpose machine which replaced on balance less than one man would be of very marginal interest. The 'last man' would be liable to linger at his post for quite a while! This point is of some importance. Automation is found in patches here and there. No factory is homogeneously automated.

The Russians, it is true, claim to have a completely automatic factory. Study of the published descriptions of this factory, however, scarcely confirms this view. The factory produces a *part* only. In fact it produces pistons for automobile engines. It would be a mere department in some modern automobile plants. In designing this factory, the Russian production engineers have coupled the melting shop and foundry to the machine shop. I personally doubt the economic wisdom of this. A melting shop and foundry, on the one hand, and a machine shop, on the other, work to such intrinsically different rhythms that I would have been inclined to classify their coupling as of the third type mentioned above, that is to say, 'not technically easy nor very remunerative'. I may however be mistaken. Only very detailed study of costs, which are not available in this case, can demonstrate whether a given device is economic or not.

Automatic Assembly

Automatic assembly is not new. If one wants to be pedantic, one can regard a loom as a device for the automatic assembly of cloth. This takes us back a very long way into the past. Electric lamp bulbs and radio valves (and latterly television tubes) have been automatically assembled for a generation at least. Recently some significant advances have taken place in this field. Anyone who has looked inside a radio or television set will have seen a tangle of electrical interconnexions running from part to part. Each of these is a wire, the two ends of which are soldered to contact points at which other wires also are soldered. If there are 100 interconnexions, then 200 soldering operations are necessary (usually made by young women workers). These connexions have not only to be made, but inspected. The cost of inspection may be a multiple of the cost of wiring.

The first stage in mechanizing this assembly is to print the pattern of electrical interconnexions on a light board made of insulating plastic material. There are various ways of doing this, but they all amount essentially to the use at some stage of a standard printing press. The electrical components have next to be fitted on to this board. A component is typically a little cylindrical cartridge from a quarter of an inch to an inch long and from a tenth to a quarter of an inch in diameter. From its extremities project axially two leads of tinned copper wire. These components are customarily

mass-produced by the million in factories operated by sub-contractors to the electronics trade. Fixing them to the printed circuit board is effected by piercing the board with holes appropriately located, stapling the two leads through the holes, and bending the stapled ends round so that they abut on to the appropriate parts of the printed conducting pattern on the board.

The reader will be familiar with the stapling pliers which are used in offices to clip dockets of paper together. A machine to clip components on to a printed circuit board would be no different. The components would require to be fed to it rather as bullets are belt-fed to a machine-gun. This can in fact be achieved without difficulty or expense, using expendable belts of paper tape, for example. A sequence of these stapling devices, suitably registered at 'stations', accordingly staples a sequence of components on to a board fed past the stations in succession by a travelling conveyor which halts under each station while the stapling operation is carried out. On completion of the assembly in this way, it is lowered whole and entire into a dip-soldering bath and all the soldered connexions are formed simultaneously.

The manifest success of this sort of device in the U.S.A. (it is quite new, and believed to be not yet completely operating in the U.K.) has aroused great interest, and produced fairly typical consequences. First, the component designers are redesigning their products so as to make them more adaptable to automatic assembly, and, secondly, production engineers are asking themselves whether there may not be other problems which could be solved by a similar approach. In the U.S.A., experiments have been begun towards the automatic assembly of automobile engines. A wide range of relative difficulty seems to be involved. One can visualize without too great difficulty the automatic assembly of rigid products, such as engines. Floppy objects, such as body-panels, present more difficulty, and pliable objects, such as upholstery, a great deal more.

Control Engineering

Control devices are not new. When James Watt patented the centrifugal governor in connexion with his steam engine, he was only adapting a governor that had been used for some time on water-wheels and in flour mills. The thermostat is a familiar device on electric water heaters and radiators of cars. It functions as a temperature regulator, turning a source of heat on when the temperature is below a pre-assigned figure, and off when it is above. An autopilot embodies the same idea. It applies rudder to a ship, or control surface action to an aeroplane, so as to turn it to the right when it is off its course to the left, and to the left when it is off its course to the right. All such devices tend to maintain some quantity—such as, a velocity, a flow, a temperature, a direction, a pressure, a liquid level—constant at a pre-assigned value irrespective of an input which may be

fluctuating, or of an output load which may also be fluctuating. They consist essentially of the following components:

1. A 'setting' device which designates the value required to be kept constant.
2. A measuring device which generates a signal indicating the actual value in question.
3. A subtractive device which subtracts component 1 from component 2 and so generates an error signal.
4. An amplifying device which converts the error signal into a source of power.
5. A servo-mechanism which applies power to the controlled system in such a way as to cause an increase in the signal (component 2) when the error is negative, and a decrease when the error is positive. This mechanism may be linear (effect simply proportional to cause) or non-linear as in the case of on-off systems such as thermostats.

The point to note is that these systems are diabolically unstable, and 'hunt' or 'oscillate' about the desired performance instead of maintaining it constant. This is particularly true of non-linear systems. In fact, the cure is often worse than the disease, and early attempts to stabilize ships against rolling resulted in their turning turtle—owing to the designer's inability to stabilize the stabilizer.

Guided missiles have given a tremendous incentive to designers in the control field, and our understanding of the all-important but very difficult non-linear systems has increased noticeably in the last 15 years. Current progress in this field is associated with the design of simulators, sometimes called analogue computers (not to be confused with digital computers, see the next section), which are all-electric models of control systems which may themselves be pneumatic, hydraulic, aerodynamic, etc. Apart from aeronautical and marine uses (for example, the Denny-Brown ship-stabilizer), the most important field for control engineering appears to lie in the chemical industry, where continuous processes involving multiple feed-back loops may, if unstable, be highly dangerous, owing to 'surging'.

Control engineering is, from the standpoint of its importance, in somewhat marked contrast to the other topics embraced by 'automation'. In all these fields the advances have been primarily practical and empirical. In control engineering the advances have been mainly theoretical. This has led to an interesting situation in which control engineering terminology has been found to have a wide field of application in quite unrelated directions, notably in the physiology of the nervous system and in economics and sociology. In so far as it avoids control engineering terms, the language of political controversy in economic matters is becoming increasingly archaic.

Communication Engineering—Computers

In expounding an unfamiliar subject, two types of difficulty may be encountered—conceptual difficulties and complexities. In expounding the *modus operandi* of a digital computer, the difficulty is of the second kind. There is no conceptual difficulty, but the reader cannot be expected to follow an explanation involving the interaction of parts when these are numbered in thousands.

The following general picture can however be attempted in terms of certain familiar devices: the Morse code, a clock, a gramophone record, a telephone, and the operation of dialling a telephone number to an automatic exchange. These devices may be used for the purpose of illustration as follows.

The Morse code is known to represent numbers and letters of the alphabet as combinations of dots and dashes. Let it be supposed that we are dealing with a modified code in which a dash is represented by *the absence of a dot*. In order to be able to discriminate between the absence of a dot and a pause between dots, we suppose further that the transmission of information in the code is coupled to the ticking of a clock. The absence of a dot is then equivalent to suppressing a 'tick'.

Suppose next that we have a gramophone record, dictaphone, tape recorder or some such device on which 'ticks' transmitted by a microphone can be recorded (written) or reproduced (read).

Turn next to the telephone. The reader will be familiar with the fact that a telephone can be used in two ways—either for sending a message, or for dialling a number. When dialling a number, one can hear the succession of 'clicks' or 'pops' which occur when the dial is released, and which are the means of activating a response at the automatic exchange, whereby a circuit is set up connecting the subscriber to his correspondent.

Lastly, conceive that the telephone is operating to a rhythm ultimately derived from a clock, and that it is transmitting coded letters or numbers stored on the gramophone record or 'store' in such a way that during alternate periods the device treats the information from the store first as a dialling signal and then as a message. There is no distinction in kind between dialling signal and message. Both consist of clock 'ticks' with some of the ticks suppressed according to the code in use. The difference consists entirely in how the circuitry of the machine treats them. As described here, it treats them as an alternate series: dial—message: dial—message: dial—message.

The effect of such a design is that the machine will perform a programme of operations in accordance with the coded 'information' on the record or store. If the unit alternation dial—message results in an operation of the form 'contents of store A via route C to store B', and C is the accumulator of an electrical adding machine working in the appropriate code, the effect

will be that some number stored at A (A is usually called its address) is added to the number in the accumulator and transferred to store B (address B). A, B and C are merely *numbers* suitably coded.

Those familiar with accountancy will recognize that this is what an accountant is continuously doing: taking a sum from one account, adding something to it, perhaps, and transferring it to some other account (which could be identical with the first). For example, a bank balance might be extracted, credited with the sum on a pay-in slip or debited with the amount of a cheque, and the balance thus modified written back into its original position.

The importance of this to accountancy lies in the simple fact that, these devices being all electronic, the clock 'tick' which controls the basic rhythm of the machine can proceed at the rate of a million ticks per second. This is high-speed accountancy with a vengeance!

It is much more than that, however, for so spectacular an increase in speed opens up whole new territories for exploration, inasmuch as commercial or managerial calculations too laborious to be undertaken otherwise, become possible for the first time: calculation of optimum traffic routing, for example.

Alternatively, these machines open up a new technique in the field of management accountancy, so called 'management by exception'. In this instance, management only receives in the first place such information as appears statistically significant and requiring action. The computing device can select this information from the total information in its store according to criteria laid down for it in advance by statisticians and mathematicians.

Lest it be imagined that this would lead to a managerial rigidity confined to a framework of rules laid down in advance, it should be added that with machines of this kind management can have as much more information as it pleases to call for from moment to moment, by an operation equivalent to 'changing a gramophone record'.

Computing machines of the electronic digital variety are highly novel. Historically, the first such machine produced its first useful result a bare eight years ago. However, a flourishing industry is already based on their production. Their full potentialities have still to be explored. One most interesting field of use covers the control of machine tools. This is liable to have a very far-reaching effect on small-scale production, that is, where but one piece of some very complicated shape, such as a three-dimensional cam, is required. Reductions in working time of the order of ten or twenty to one have been claimed for devices of this kind. It might be noted that the most advanced pioneering design of this kind was inspired by an *acute and irremediable shortage of skilled labour* in the district where it was produced.

Such is the fourth topic which can properly be included in 'automation'.

AUTOMATION AND TECHNOLOGICAL CHANGE

In view of the likely spread of automation, it is desirable to have a clear picture of how the technological world reacts to changes of a novel character.

A novelty can frequently be postulated years in advance of its first *economic* reduction to practice. But a latent period of very variable length has to be presumed before this occurs. The first economic reduction to practice may be caused by one of three changes in the interim period.

First, new methods or materials may have become available. This was so in the case of Whittle's gas turbine: creep-resisting stainless steel turbine blades were available to Whittle, whereas they had not been to his precursors in the field.

Second, the economic factors may have changed in the interim, as witness the relative success of automation in Detroit twenty years after its relative failure in England. The history of retractable undercarriages for aeroplanes is another instance. Such undercarriages reduce drag. They were first proposed when air speed and drag were both too low for the reduction of the latter to be worth while. As air speeds rose, retractable undercarriages became economic.

Thirdly, a special purpose may emerge which requires the use of the novelty irrespective of cost. Such was the history of silicone greases which found their first big field of application for certain special purposes in nuclear energy plants.

Once the first economic reduction to practice has taken place a number of consequences follow. Duplicate devices cost much less than prototypes. Costs come down, and what was barely profitable to start with becomes progressively more so as time goes on.

Secondly, designers crowd into the new field opened up. Early designs are minutely examined and prove on analysis to be relatively clumsy and expensive. A wave of redesigning takes place, and relevant gadgetry multiplies without limit. Costs accordingly come down still further.

Thirdly, as costs are progressively reduced, so new fields of application become more profitable. A novel technical process is thus converted into a technical snowball. Nothing succeeds like success.

Something of this sort is bound to occur with automation, whichever of its sub-divisions we choose to consider. We are scarcely at the beginning of 'redesign for automation' as distinct from 'production by automation'; nor has factory redesign for automation yet had much consideration. In fact, 'reunification in continuity' cannot occur if components of manufacturing processes requiring 'reunification' are conducted at opposite ends of the plant site.

In its physiology a factory resembles an arthropod, such as a lobster, rather than a verbetrate, such as a horse. Its rigid framework or skeleton

—its building—is outside, not inside, its functional organs. The framework cannot grow accordingly. A verbetrate and its skeleton grow in proportion to one another. An arthropod must 'moult' at regular intervals if it is to grow. Factory growth is not dissimilar. At intervals a new factory is built on an adjacent site and the old factory dismantled. We must accordingly wait for a new generation of factories in order to see the full consequences of automation. The regeneration of factories is, however, a continuous process like the human birthrate. For this reason we cannot expect to see spectacular results. For a long time to come the evidences of automation must be restricted to a patch here and a patch there, as at present. Any technology which operates with long-life facilities cannot by and large produce short-term revolutions.

THE SOCIAL AND ECONOMIC CONSEQUENCES

One of the surprising disclosures resulting from the interest shown in the social and economic consequences of automation, and the controversies it has aroused, is that no one appears to have any clear ideas how social and technological changes accommodate themselves to one another. Does advancing technology create employment or cause unemployment? Has society a normal state to which it tends to revert? Is it one of massive structural unemployment from which it has to be rescued? Or is it one of full employment and inflation which has to be kept in bounds? Alternatively, has society no stable state? Is employment oscillatory and highly disturbed? Are technological changes the sort of disturbances which cause oscillation? There seems no accepted doctrine on any of these points.

Let me first consider the integration of technical and social changes.

Advancing Productivity

Whatever the consequences of automation may be, they cannot differ from the consequences of any other advance in productivity—for an advance in productivity is what automation amounts to.

Consider, for example, that in 1956 we enjoy per capita all the goods we consumed in 1906 and many more besides—automobiles, television sets, antibiotics, and other products which scarcely existed or did not exist at all 50 years ago. How is it possible to make, per head of population, all that we made 50 years ago and more besides? It *can* only be because we can make the type-products of 1906 with less effort than was entailed 50 years ago, the displaced productive-power being redeployed for the manufacture of, for example, television sets. In fact, productivity per head has been advancing at about 1½ per cent compound interest per annum for the last

50 years, with a marked acceleration recently; the present figure is thought to be as high as 3 per cent. How is it, then, that we enjoy full employment in 1956? Is it a coincidence? Were there no television, would all the people employed in manufacturing television sets be unemployed? If people could not buy television sets, would they buy vacuum cleaners instead? Would there be higher employment in other trades accordingly? Has technology a reservoir of ideas for consumers' durables, capable of absorbing redundancy, caused by advancing productivity, for an indefinite time to come? If any substantial thinking along these lines preceded public interest in automation, few of its conclusions seem to have found their way into circulation in time to be of any use in discussions of the matter.

In these circumstances, I can only give my own conclusions in the form of assertions.

The first is that technology as such can create neither employment nor unemployment. The only component of society which can create employment or unemployment is the money market.

The second question, concerning the normal state of society, I must answer with a second and qualified assertion. Are we talking of the pre-Keynsian or post-Keynsian economies? Keynes claimed to know the answer to the cause of trade cycles, and F. D. Roosevelt gave his exponents a chance to prove it. In the opinion of most people, they succeeded in doing so. We are all Keynsians now. In the pre-Keynsian era the normal state of society *was* one of deflation and structural unemployment. The investment rate tended, as it were, to bump along the bottom of its permissible value. An economy in this condition *is* near the instability level and over-sensitive to disturbances which cause oscillations of the 'boom and slump' variety, with their attendant unemployment in the slump phase of the trade cycle. In the post-Keynsian era the investment rate has, by central government and banking action, been kept up to a permanent level high enough to maintain the economy in a reasonably safe, stable, non-oscillatory condition. At the price of some inflationary writing off of old capital, capitalist society has achieved the stability denied to it by Marxist theory. It appears that full employment, with some inflation, has come to stay; and most people are prepared to tolerate the inflation for the sake of the increased stability. There has been a real change. To the cynic murmuring 'Plus ça change, plus c'est la même chose,' I would reply that change *can* be real. The change from the mercantilist to the laissez-faire outlook was a real change. That from the pre- to the post-Keynsian outlook is another.

The third question concerning the supply in perpetuity of novelties such as television can be answered in the affirmative, even though these novelties will not necessarily be technical in character. A sewing machine is a novelty for the housewife who has not got one. So long as man's standard of living is distributed over a broad range and there is an adequate investment and

employment policy, the raising of the standard of living of the lower levels in society to that of the higher can absorb any skill displaced by advancing productivity. The only issue therefore turns upon how society accommodates itself to advancing productivity locally and over short periods.

Labour Turnover—Retirement and Recruitment

Retirement and recruitment would appear to be the normal mechanism whereby technology is integrated with social change. As happens too often where the under-endowed social sciences are concerned, the need to provide an authoritative answer to snap-questions in this field finds us short of the requisite information. The following picture cannot however be very far from the truth.

First, a working career begins some time after school-leaving age at 15/16, and continues, in the majority of cases, until retirement at some time before 65. As a first approximation, it thus occupies 50 years.

There is accordingly a basic labour turnover of 2 per cent due to human senescence. It is much greater locally, however, since not many men remain in the same job or employment that they entered as apprentices or on leaving school. If the average man were to hold five jobs in the course of his working career, representing an average of 10 years apiece, the basic turnover in any factory would be 10 per cent.

Women frequently retire from work when they marry and start a family, and resume it again on completion of their principal life occupation as mothers: two 10-year periods, covering the ages of 15/25 and 45/55, are likely to be spent in employment. This would correspond to turnovers of 10 per cent if only one job were followed in each period. If two jobs were followed, the turnover would be 20 per cent.

It is not always easy to check these figures, owing to the inadequacy of available statistics. It is known, however, that there are two classes of employed labour, one known as stable labour, usually of a skilled variety, and the other as unstable labour, the former having a relatively low rate of turnover, the latter a relatively high rate. Gross turnover averages the two.

For example, in the U.K. the figures for all industry for July 1956 were:[1]

	Male	*Female*	*Total*
Engagements and additions (per cent)	2.7	4.2	3.2
Discharges and losses (per cent)	2.8	4.4	3.3

These are monthly figures (five weeks in this case), and it will be noted that they balance to within 0.1 per cent. The annual turnover appears accordingly

1. *Ministry of Labour Gazette*, July 1956, p. 271.

to be of the order of 30 per cent. It seems clear that a spontaneous turnover of something like 30 per cent can easily accommodate a 3 per cent displacement caused by advancing productivity at constant production. (In fact production is not constant but increases, so that any redundancy due to advancing productivity is less than the 3 per cent advance in productivity itself).

The Changing Pattern of Society

As technology advances, the requisite pattern of skills changes across the years. Old skills become obsolete, new skills are called into being. Jobs that once required skill are performed by the unskilled, while jobs once the function of the unskilled are transformed so that skill is required in their performance.

In one sense, however, the net changes are in the direction of increasing skill of a kind at the expense of un-skill. The proportion of society's members occupied as hewers of wood and drawers of water is dwindling, a higher standard of education is required of all, and the proportion of the highly skilled tends to increase progressively.

This process is frequently described as the up-grading of labour. If a hard task once performed by human muscles is transformed so that it is effected by a machine requiring a skilled operative, we say that the labourer has been up-graded into a machine minder.

It is important to remember that the word 'up-graded' has a statistical and not an individual meaning. The individual labourer may only rarely be up-graded; he more usually changes his job. Some labourer's son, however, ceases to follow his father's calling, and becomes a skilled operative.

Let it be supposed, then, that some skilled man is made redundant by a new technical process. What exactly happens to him as an individual? In the first instance, he merely changes his job and fills one of the vacancies that are constantly occurring owing to retirement of fellow workers possessing his skill, or to their leaving their job spontaneously for some reason or another. If his skill is 'on the way out', the consequence of a long-term trend, then there will be no demand for apprentices to replace those who retire and he will find himself a member of an aging group of craftsmen, the demand for whose skill diminishes as their numbers dwindle.

This is the broad picture. What we require to know is how a process, which is clearly self-balancing in a statistical sense, operates equitably in its effects upon the individual. It is assumed above that the craftsmen displaced by a new technical vacancy can be redeployed. Can they however be re-deployed without personal hardship?

Strain and Stress

In engineering jargon a strain is a displacement, a movement of material; stress is the force that always appears as a concomitant of strain, resisting it, restoring the *status quo*. For a given strain, stress will be higher in a material such as steel than in one such as aluminium or lead.

There are some advantages in carrying this terminology over into sociological nomenclature. Social strains will then denote displacement, dismissal, redeployment, and change of status or income, while the concomitant stresses will be psychic forces and their manifestations, resentments, strikes and so on.

In the process of integrating social change with technological change, we must assume that there will be strains. The problem is simply how to keep down the stresses.

Consider, for example, the strain represented by displacement and redeployment of labour. What will determine the magnitude of the stress?

Stress will clearly be least if the individual can be redeployed at the same occupation and wage within the same factory. Even in this case, stress will not vanish, for there will be anxiety until the issue is clear, and anxiety, even if finally relieved, will leave a scar of resentment.

Stress will be greater if the individual has to seek alternative employment. There will be anxiety until it is secured, and there may be dissatisfaction with its nature. This dissatisfaction will be least if alternative employment is secured in a locality no farther from home. It will be much greater if change of employment involves change of district. Stress will be greatest if a change of occupation is involved, especially if a skilled craftsman, after a period of unemployment, secures employment as a labourer at a lower rate of pay.

Much of the report of the Department of Scientific and Industrial Research on automation is concerned with techniques for keeping the stresses down, with particular reference to re-training of displaced personnel. How realistic re-training will prove to be on the material plane, it is difficult to foresee. It is hard to teach an old dog new tricks. Its advocacy, however, is real on the psychological plane.

It is not enough that justice be done: it must also be *seen* to be done. It seems but fair that if a man's occupation is transformed by a machine, then he should be given a chance to be the man to work the machine if he can; that if his skill is in danger of redundancy by other men's actions (the whole complex of actions by management, designers, technologists, scientists and others responsible), then these actions should include re-establishing him at his old earning power; and that the cost of doing so should be part of the *true cost* of the technical development rendering him redundant. It is perhaps worth noting that this approach is advocated by scientists and engineers, and is a welcome sign of their sensitivity to the problems they help to create.

It might be helpful to introduce here two concepts currently used by the

communication engineer: that of 'signal' and that of 'noise'. A signal is whatever can be recognized and acted upon. Noise is the component of a signal which contains no information and cannot therefore be a basis for action. Social hardships may be considered in these terms. A certain amount of hardship is inevitable as the price of being alive. It is always happening to someone. Should society treat it as signal or as noise?

Thus in the United Kingdom, for example, 20,000 people die by violence every year: 5,000 on the roads; 5,000 from industrial accidents; 10,000 from domestic accidents—they fall out of windows, out of bed, downstairs, into the fire or off ladders; they electrocute themselves in the bath, are struck by lightning or eat poisonous mushrooms; they commit suicide. These accidents occur after the traffic police, the factory inspector and society at large have done whatever is possible to ensure that they do not occur. They are what cannot apparently be helped. Yet each of them means hardship or sorrow for someone. I suggest that they should be regarded as society's 'noise level' of personal misfortune. In this sense, the misfortune of the man in a thousand who, under present conditions of full employment in the United Kingdom, may be unemployed for so long as 10 weeks if he loses his job, is 'noise'. When society has paid his unemployment relief, it has done all that can be done. Whether the victim reacts with fortitude or self-pity, there seems little his neighbours can do about it, save by way of sympathy and small kindnesses.

But structural unemployment, by contrast, is not 'noise'; it is a 'signal' calling for action.

BACK TO AUTOMATION

With a firmly established picture of how the integration of social change with technological change takes place, we can return to our original subject. Automation does not differ generally from any other advance in productivity, and everything that has been said here applies not only to automation but to any other technological advance. Strains caused by automation will be no greater than those caused by any other technological advance. The stresses associated with them will be determined by the manner in which they are dealt with, and this will not be affected by the technological origin of the strains.

All that remains for consideration therefore is the number of occasions on which strains will arise. Reverting to the engineer's concepts: will the social strains arising from automation be signal or noise? There already seems to be sufficient evidence to assert that they will be indistinguishable from other background strains.

Let us consider the components of automation in order.

Transfer machining is now some 10 years old and its introduction seems to have been as strain-free as that of any other new process. It has so far been employed in the context of consumers' durables, such as automobiles, and its use has been initiated to clear production and bottlenecks in factories where total employment is rising. It is difficult to see why it should cause more strain in the future than in the past.

Automatic assembly has been employed for so long in the electric-lamp bulb industry that its introduction elsewhere should not cause alarm. In the context of the electronics industry (printed circuit assembly techniques) any displacement it effects is likely to fall on young female labour having a very high rate of spontaneous turnover. There should therefore be no serious problem here.

Control engineering techniques are already widely employed in the chemical industry, which uses them pre-emptively. This industry characteristically employs but few direct operatives as compared to maintenance engineers. It is only the plant operators who will be affected by automation, and they are more likely to be assisted than displaced. (Note that an autopilot does not replace the pilot of an aeroplane. It merely lightens his task.) Where but few are employed, few can be displaced.

Data processing and computerized accountancy is the most interesting of the four cases calling for analysis, because a digital computer is a more fundamentally novel and powerful device than any other employed in automation. Accountants are likely to be the victims, if there are any, particularly accountants concerned specifically with the mechanics of book-keeping. It must be remembered in the first place that such accountants are not generally employed in local concentrations; with rare exceptions (such as, in the U.K., the City of London, and the National Health Insurance offices in Newcastle) they never constitute local industries to be compared with coal-mining, shipbuilding, or automobile manufacture. They are distributed over all industry. Secondly, the computerizing of an office routine is a long and tricky business. Those qualified to operate it are at present an almost microscopical handful, and suitable recruits are very difficult to find. Computerization, therefore, can scarcely proceed very fast, even if the production difficulties involved in manufacturing computers on a large scale could be overcome. Thirdly, accountants and clerical workers generally are at present in short supply; there is little prospect of automation doing in this field more than it has tended to do in every other field where it has been introduced, that is, to clear a bottleneck.

It must be remembered that a new facility presents the user with three opportunities. To perform a traditional task more cheaply, to perform it better for the same cost, and to undertake some non-traditional task. The importance of computers, in the opinion of those who have used them most, appears to lie in the second and third of these opportunities.

Having considered the four types of interaction which automation may have with industrial society, we may conclude this section with a review of those industries which are unlikely to be affected by labour displacement as a result of automation. In each case the fourth type of automation, computerized accountancy, will be disregarded, since clerical work is more or less the same everywhere and has been dealt with above. With this qualification, industries may be split into the following groups.

1. Industries where automation is unlikely to be applied, for example, agriculture, mining and transport. All are highly mechanized, but the subspecies of mechanization which pertains to them does not seem to be automative in character or to lend itself to further automation.
2. Highly mechanized industries where automation seems unlikely to be applied, other than as an occasional auxiliary. The textile industry based on natural fibres is one such case. No doubt textile machinery can be improved and productivity raised, but that does not by itself constitute automation. Transfer does not seem to be a problem involving many operations, though the auto-doffer for ring spinning frames has something of the transfer idea in it. Control-engineering techniques seem unlikely to be more than useful auxiliaries. They are unlikely to cause labour displacement.
3. Industries basically similar to the chemical industry, that is, those which have low direct labour costs and where automatic control techniques are more likely to improve the performance of the operatives than to render them redundant. All continuous processes, and plants operating them, such as sheet rolling mills, would fall into this class, together with brick-making, iron and steel works, coke ovens, gas works, electrical generating stations, and so on.
4. Industries such as soap and beer manufacture, where an initial operation resembling those of the chemical industry (group 3), for example, soap boiling or brewing, is followed by a highly mechanized stage (similar to one of those in group 2) for distribution purposes, for example, soap tableting and packaging, and beer bottling.
5. Trades involved in the manufacture of heavy capital goods, such as, housing and structural engineering generally, and shipbuilding.

The trades most likely to be affected are those already aware of their involvement with automation, that is to say, those engaged in manufacturing consumers' durables. These trades are already highly sensitive to problems of redundancy, as they are always the ultimate victims of a slump or a fiscal policy based on restricting consumption. In this connexion, it should be noticed that the recent increase in purchase tax on automobiles and the restriction of credit for hire purchase in the U.K. has dislocated the employment situation in the British motor industry far more than the installation of transfer machining ever did.

BENEFITS AND LONG-TERM EFFECTS

Having looked on the dark side of automation, in so far as it has one, and decided that it is not so dark, let us dwell briefly on its advantages. First, it must be regarded as an advance in productivity, and welcomed accordingly as the type-contribution to a continually rising standard of living. In this sense, it is but the current phase of a process at least two centuries old. Its adoption will be enforced by competition. Whether misinformed theorists like it or not, automation will be adopted. The issue, as the DSIR report clearly demonstrates, is whether we put it to good use or not.

It may however be more far-reaching than a mere current advance in productivity. In a section of his book specially written for the American translation, Friedmann[1] considers automation, without however defining it very clearly (he seems to think mainly in terms of transfer machining). He concludes that it may offer an avenue of escape from the problem whose answer partly baffles him—the monotony of sub-divided repetitive tasks, and the elimination of joy in work from the worker's daily routine. Personally I doubt this being so, and yet there is a sense in which I believe Friedmann may be right if one takes a long enough view of the matter, though the solution which he foresees will not, I think, any longer be called 'automation' when it becomes manifest.

I believe, in fact, that our society is emerging from the worst of the machine age into better times, and that automation is a symptom of this partial emergence. There has been a trend to 're-unification in continuity' for some time, and automation is an aspect of it. Increasingly, continuous processes replace batch processes, and observational skills are becoming as highly sought for as manipulative skills. The passing of the old-fashioned foreman, old-fashioned manager, and old-fashioned boss are palliatives. The tyranny of the assembly line (which actually affects only a minority, though a vocal one, of workers) is becoming less unendurable, while in patches it is being mechanized and integrated—though only in patches and that but experimentally. If Friedmann is correct in his hope and I am correct in my belief, then our society has escaped spiritual destruction, though perhaps by a very small margin.

THE LABOURER

My own concern has from the start been with the man who is not going to be affected by automation rather than with the man who is—the hewers of wood and drawers of water who do the heavy labouring work for a society

1. Georges Friedmann, *Industrial Society*, The Free Press, Glencoe, Illinois, 1955.

which does not know how to lighten their task. Typical of such are the coal-miner, the stevedore, the road-mender, and the builder's labourer. The miner has the dirtiest, hardest, and most dangerous occupation in the world. The stevedore ranks second. The road-mender and the builder's labourer are subject to every hazard of wind and weather. No matter how highly mechanized the task may be, the unpleasant and dangerous character of coal-mining will remain so long as coal is black and must be won underground, subject to the hazard of a roof that may fall or of fire-damp that may explode. What is going to be the effect on the community of harbouring within it a dwindling minority of essential workers who live a life unknown to the rest of the community, subject to dangers unshared by the rest of the community?

The life of a fisherman is hard; it is also dangerous. But the fishing fleet does not sail in and out at the beck and call of a siren, and if the sea is dangerous it can also be beautiful. There is a 'lure of the sea'. Is there a 'lure of the mines'?

Two problems require to be faced, and we know the answer to neither. The first is how to lighten the essential burden of the miner's occupation. The second is how to integrate his outlook with that of the rest of the community. These are indeed baffling problems.

SCIENCE AND INDUSTRIAL SOCIETY

The function of science is to observe, explain and expound. It is not its function to take sides in controversy, for controversy only arises where authoritative exposition is lacking because science has nothing to say. In so far as scientists have any part to play in controversy, it can only be by placing the facts at the disposal of all contestants so that they may see the nature of their dispute more objectively. In writing of automation, I have endeavoured to keep this ideal before me. The main problem our society has to resolve is the inability of man at any level of specialization to undo his mythical fall, and re-integrate himself. This fact is basic. There is no difference in this respect between worker and manager, and the fall is replicated at every level, manifests itself in every occupation, and repeats itself every day as, grasping at a more abundant life for ourselves, we initiate developments whose consequences we cannot foresee. It appears, moreover, that this cannot be otherwise: as we re-integrate ourselves in one respect, we are disintegrated in some other. The Marxist attempt to re-integrate society economically merely disintegrated whatever tender growth of liberalism once existed in Russia. The political liberalism of Western Europe merely connived at gross exploitation of man by man in the economic sphere.

Our current dangers lie in the division of society into two hostile subgroups, a managerial group relatively free and a workers' group relatively

unfree. Their unfreedom and their discontents are however of a sophisticated character. Although the cleavage follows the old line of demarcation between rich and poor, riches and poverty are not the current issue between the contestants, for the standard of living in the West is now so high that poverty in the old sense of the word scarcely exists. The current issue, barely acknowledged to be so, is more freedom in relation to work. It may well be the case that as freedom spreads, any residual bondage is felt to be increasingly savage. It may be the case that where bondage is least, there it is felt to be most insufferable.

For this reason I regard our current discontents as sophisticated. They could not occur at a lower level of evolution. On all such matters, however, we need far more information than we yet possess. We cannot give manager and worker an objective picture of one another, because we do not know enough about their interactions. We can, however, recognize components of hostility, of suspicion, of anxiety, and its attendant aggression. These are psychological realities. Their causes may not correspond to material realities. Therefore, it seems, good will and trust must to some extent be dependent upon objectivity springing from dispassionate accumulation of facts.

Automation is a material reality. It is also a psychological reality. The two realities do not necessarily correspond. As a material reality automation is a source of wealth. As a psychological reality it is a source of fear. May this present essay help to show how the two realities can coalesce, for such is the function of the social sciences in their application. They have few functions of comparable importance to the contemporary world.

THE IDENTITY OF THE PERSON— ITS IMPORTANCE FOR THE INDIVIDUAL AND FOR SOCIETY

by

CHARLES SANNIÉ

Dr. Sannié is Honorary Professor at the Faculty of Medicine, Paris, and Professor of Organic Chemistry at the National Museum of Natural History. Since 1930, he has been Director of the Identité Judiciaire (Criminal Records Department)—the third to occupy that post, following Bertillon and Bayle. He is the author of a number of works on chemistry and forensic science and of various reports and books on criminology.

If there is one concept of which each of us is aware in the innermost recesses of his being, it is surely that of his own personal existence, of his independence vis-à-vis all other living creatures. All our reactions—psychic, moral, religious or biological—find therein a personal, an inner, support so strong that most of our acts are determined by this feeling of our individuality.

But the notion of identity extends far beyond the limits of the individual. All who are interested in the problems of life have been led to extend it to ever wider zoological groups, establishing thereby the concept of race, species, genus and order. It is possible to understand the countless variety of living creatures only through this classification which, starting with the individual, ends with the huge aggregates formed by the zoological groups.

In this study, the closer we get to the individual the narrower become the characteristics of the species, then of the race or variety. Here, morphology is not the only thing to be considered; the dog, *Canis familiaris,* provides one of the most striking examples. As Isidore Geoffroy St-Hilaire wrote a hundred years ago: 'Where in the list of mammals should we find not only two species of the same natural genus, but two neighbouring genera differing from each other from the point of view of the development of their brain and skull to the same extent as do the barbet spaniel and the pug from the majority of other dogs?' Apart from morphological identity, which is often concealed by considerable variations in shape or size, we must thus have recourse, in order to define the species, to the biological notion of interfecundity.

It is thus sometimes more difficult to define accurately a race than an individual. Anyone who has kept dogs will have no difficulty in recognizing

his own dog from among a hundred other similar dogs, whereas the naturalist has difficulty in defining the species dog. The individual possesses certain sufficiently specific characteristics to enable persons in daily contact with him to recognize him without difficulty.

This notion of individual identity applies, of course, throughout the scale of animate beings. If we cannot distinguish one bacterium from the next, one fungus from another of the same species, this is because we are not able, or do not know how, to distinguish the characteristics which differentiate them. But these characteristics exist, and a close study very often makes it possible to discover them.

Identity, whose importance is fundamental for the living creature, can be considered from a great many points of view. We shall not attempt here to deal with the question in general, but only to define it in respect of the human species, taking in turn its various aspects.

PSYCHOLOGICAL IDENTITY

Of first importance in the case of man is the consciousness that each of us has of his 'self', of what may be called his psychological identity. An essential characteristic of the human being is the sense of his own individuality which everyone possesses as much by instinct as by reason. Descartes's famous aphorism: 'I think, therefore I am' perhaps expresses it most accurately. This notion is so normal that the loss of it is regarded as pathological; it is one of the forms of madness. It appears so universal that it has become part, in one form or another, of the majority of religions. It has been the subject of countless debates between philosophers and psychologists, which we need not discuss here.

As the share of the intellect in the sense of personality becomes stronger, that sense broadens, embracing a greater number of aspects, but it loses in precision. Biological or morphological identity have material bases that are more or less easy to determine and, even if we do not know them in detail, we can at least always conceive of their existence. But as soon as we enter the psychological or the psychical sphere, facts become less and less clear-cut until finally they are completely obscured, giving place to purely subjective notions that are highly controversial. However, in spite of this imprecision, the sense of one's own personality is probably as strong and as widespread among animate beings as is the maternal instinct, even though each of us can only know with certainty what pertains to his own life.

BIOLOGICAL IDENTITY

Anyone who analyses by chemical or biochemical methods a large number of living creatures belonging to the same species, or even to widely differing species within the same genus or the same order, cannot fail to be struck by the similarity between their essential components, and even between their metabolisms. For instance, among all mammals, man included, the same protides, glucides and lipides are to be found, and the same mineral salts in fairly equal proportions. They all follow an identical procedure in breaking down their food or building up their tissues, with the aid of the same series of reactions and the same enzymes. The vitamins they need, the hormones which co-ordinate their biological reactions are similar, often interchangeable. Their excreta are identical, varying only in the proportions according to the source of food.

There are, of course, a few differences. The digestive mechanism of ruminants, especially in their stomach, is not the same as that of carnivores. This is due to the nature of their food—plant cellulose cannot be hydrolyzed by the gastric juices meant for digesting meat. Similarly, with some species certain metabolisms result in very specific waste products. Thus man is able to break down the nucleoproteins in his food only as far as the uric acid stage, whereas other omnivorous creatures break them down more completely. But these are merely details, which are in no way confined to a particular species. This inability on the part of the human species to transform uric acid is, in fact, found again in a certain breed of dog—and in one only!

No one, however, would dream of casting doubts on the fact of the biological individuality of every living creature. Each individual in a given species is made up of the same essential elements as other individuals in that species, but necessarily differs from them either by slight variations in the structure of those elements or by their different assemblage.

Given the extraordinarily large number of individuals in the same species, and—to confine ourselves to the human species—given the fact that there are on this earth about 2,500,000,000 human beings, how are we to explain that such a vast number of men built on the same structural model should all differ from one another? Not only, among these two and a half thousand million men, is none identical with another, but they each differ from their parents and their children, and that has been so, no doubt, throughout untold generations. Moreover, it is almost certain that their organs, humours and even their individual cells differ from all other existing cells, and this is doubtless one of the reasons why the grafting of organs is very often a failure.

The research carried out since the beginning of the century on the constitution of the protides and glucides, together with the spectacular advances recently made in this field, have made it possible, if not to clear up entirely

the problem of individual or cellular specificity, at any rate to understand how it could be brought about.

Protides, which are specific components of all living beings, are formed mainly by a concatenation of simple molecules, the amino-acids of organic chemistry. Each of these amino-acids possesses one or several organic acid functions, and one or several basic nitrogen functions. The acid function of an amino-acid can be combined with the basic amino function of another, with the loss of one molecule of water, thereby giving a new body, a di-peptide, in which there still exist at either extremity an acid function and a free basic function. When this process is repeated a number of times it gives rise to 'polypeptides', able to condense together several hundred simple molecules of amino-acids. We know how to synthesize aggregates which include a maximum of 20 amino-acids, and they have served as models for studying the structure of natural polypeptides, which are considerably more complex. This constitution has been confirmed by the acid or fermentative hydrolysis of protides, which first of all gives simpler though still very complex molecules—peptones—then a whole series of polypeptides from the simplest to the most condensed.

At the present time, we know of 28 amino-acids, that is to say, most, if not all, of those which exist in protides. We have been able to isolate them from the products of the complete hydrolysis of the latter, to identify them, establish their structure and reproduce them by a process of synthesis. Finally, we know, as already mentioned, how to condense them into simple polypeptides, and even how to reproduce in this way natural polypeptides.

These explanations are necessary for an understanding of how the protoplasm of every living cell can attain a degree of specificity that explains not only the individuality, the identity of each living being, but even that of the cell. Each protein molecule having a molecular weight of several thousands, or even several tens of thousands, thus contains hundreds of thousands of amino-acids. The 28 fundamental types of these acids can combine in every possible way, and make it possible to effect *a priori* a number of combinations equal to 28 (number of known amino-acids) raised to a power equal to the number of amino-acids present in the protide molecule. If the latter is composed of 1,000 acids and all types of acids are represented, the number of possibilities that the combination of these acids allows for will be 28^{1000}.

Such a number no longer possesses any real meaning for our intelligence; it far surpasses the biggest numbers employed by astronomers to express the interstellar spaces, and we can no longer either write it down or even clearly conceive of its magnitude. But it enables us readily to ascribe to every animate being, and even to each cell of every animate being, a specific protide, different from all other protides in time and space.

But cellular specificity is still more complex. The protides composing the protoplasm are not simple chemical compounds; they play a part in the

morphology of the cell by associating themselves with the other components of living matter, the glucides, lipides and mineral salts. Although the composition of the glucides and lipides is infinitely simpler than that of the protides, they also, especially the glucides, can themselves form complex molecules such as glycogen as they condense. They can unite in variable proportions with the protides to produce colloidal complexes, micellae, in a state of equilibrium, in which the relative proportion of each component can vary *ad infinitum,* thus further increasing the causes of cellular individuality.

Thus, even taking into account more recent research which has shown that the number of amino-acids in the molecule is not indeterminate, but that they are periodically distributed throughout the polypeptide chain, the absolute specificity of the protoplasm of each cell is a perfectly admissible theory. Even now we can go so far as to assume that in addition to this individual specificity of the cell, there exists a specificity of the species, which is the reason why the albumen in dog's milk is not the same as that in human milk, although it has a similar chemical structure. Probably cellular protoplasms differ from each other by the 'secondary' bonds in the polypeptide chains, owing to more or less loose molecular associations or to hydrogene bonds, or again to colloidal associations with the other components of the cell. Further evidence of the biological identity of man is afforded by those manifestations of idiosyncrasy whereby some human beings display greater sensitivity to various substances and react, for example, pathologically to the ingestion of certain foods.

But proof of the individuality of every one of an individual's cells is insufficient for a biological delineation of his identity. A man is composed of tissues and organs similar in structure to those of all other beings of the same species, and yet his body is a unit that is distinct from all the other human bodies. Morphology is powerless to explain why this is so, and we cannot at present explain what it is that distinguishes one man from another biologically. It is certain that cellular specificity is of paramount importance in the individualization of our tissues and organs, but we are still quite unable to say how it works.

There is, however, a tissue in which we are beginning to glimpse the specific factors of at least a group of individuals belonging to the same race, if not of an individual. It has been possible to isolate plasmatic protides from the blood; these are found to differ, at any rate in their relative proportions, according to the individual. We know, furthermore, that in the globules and plasma there are complex compounds the chemical nature of which is only beginning to be understood, and which make it possible to classify the various types of human blood in clearly defined groups. These factors, which were limited at first to the four main blood groups—A, B, AB and O—are now far more numerous, and new ones are being discovered as research develops. Thus, groups M and N, the factors S and P, finally

the Rhesus group, itself broken up into numerous combinations, have been isolated. We are moving towards a more and more advanced individualization of the blood of each human being. That is a new conception which would have been thought revolutionary only 20 years ago.

Again, chemical knowledge of blood pigment, haemoglobin, has shown that several different sorts exist. That of the foetus is not the same as the adult's and numerous sorts are found in some diseases. The blood of each one of us may therefore be our own particular blood, different from everyone else's. In all probability this is the case with all the other tissues, and these specificities taken together are the basis of biological identity.

If these facts are true, if each individual carries within himself, in his cells, blood and tissues, the factors of his identity, we can then explain the transmission of some of these to his children. Beside certain individual, mainly morphological, characteristics which are not transmitted or only partly transmitted, there are characteristics of constitution, race or species which inevitably recur in our descendants. The distinction between the two is sometimes extremely subtle, because the proofs of biological identity are themselves extremely subtle. The child is the product of the amalgamation of factors transmitted by the father and the mother; some are dominant and others are recessive, and the laws of heredity, which are now well known, enable us to understand why he resembles both father and mother while at the same time being quite distinct from either.

Biological identity, in the case of the blood factors, and its hereditary transmission are extremely important in the social and judicial spheres.[1] The way the groups are distributed in a population provides ethnographers with the essential data for determining the concept of race and people. Their transmission by heredity is more and more relied upon in paternity investigations, and 'blood proof' is now pretty well universally accepted. Based on the calculations of probability on which the laws of heredity depend, it not only enables us to rule out with certainty the possibility of a particular paternal origin, but also sometimes furnishes a strong presumption in favour of the true paternal origin. The more we know about individual blood factors, the stronger will this presumption become, and some writers foresee the time when blood analysis will rival fingerprinting as a means of identification.

I doubt whether that end can be achieved for some time to come. Except for the case of the blood groups, we still know practically nothing about the factors of biological identity, and it is as yet far too soon to contemplate using them for judicial or social purposes. But the day will undoubtedly come when we shall succeed in isolating these factors and in classifying and identifying them—with all the legal, individual and social consequences that we can even now ascribe to certain other factors of identity. These we shall consider next.

1. See A. C. Allison, 'Blood Groups and Racial Groups', *Impact*, Vol. VI, No. 1.

MORPHOLOGICAL IDENTITY

This is the most obvious form of identity, thanks to which each of us is recognized by his neighbour. It supplements biological identity and, as it is found among all living beings, it is also a characteristic of life in general.

Human anatomy has been a fully developed science for several decades past. It is not surprising, therefore, that anatomists should have been able to pick out what, in the human body, has seemed to them special and particular to each individual. It might thus have been expected that physical identification would have been based long ago on definite anatomical facts, since nothing could be easier to observe and verify.

In point of fact the anatomist, in studying human physical structure, has always concentrated on general rather than particular characteristics. Nor is this surprising, for science is always a question of generalities. Similarly all who have sought to describe the human face and body have directed their attention only to the usual characteristics, admittedly obvious enough, but of little value precisely because they are so usual. Thus, in describing a face, people will speak of a round chin, an oval face, as if it were possible to have a polyhedral chin or face! Even anthropologists had considered the variations in morphological characteristics which they noted and measured in their subjects only in order to deduce general laws, without paying attention to the individual as such.

This deficiency proves once more that the problem of identity has not interested scientists, any more, as we shall see, than it once interested jurists, sociologists, and for a very long time the police themselves. Only when an anthropologist, Alphonse Bertillon, was led, of necessity, to interest himself in the subject in connexion with habitual offenders was it finally tackled scientifically, and resolved.

A great deal has been written about the process by which Bertillon was led to carry out his work, and all that can be done here is to give a very brief idea of it. Any reader who wants a fuller account should refer to the various biographies of Bertillon.[1]

Through his father, Dr. Adolphe Bertillon, and his grandfather, Achille Guillard, Alphonse Bertillon had, from an early age, become familiar with, and learnt how to carry out, anthropometric measurements, which between 1860 and 1890 were in high repute thanks to the fame of the anthropological schools of Broca in France, Lombroso in Italy, etc. Although he had learnt a good deal about anthropology, his general education and scholastic attainments were meagre in the extreme, and at the age of 25, after a stay in England and having done his military service, he found himself without

1. S. Bertillon, *Alphonse Bertillon*, Paris, 1941; H. T. F. Rhodes, *Alphonse Bertillon, Father of Scientific Detection*, London, 1956. The reader will find, at the end of this issue, a review of the latter work written by the author of this study.

employment and incapable of holding a regular job because of his unpredictable temperament. For the sake of peace and quiet, his father found him a post as a clerk at the Préfecture de Police, and the young man had to settle down to spending the whole day entering and checking the records of the daily batches of offenders consigned to the cells.

There was at that time no means of discovering which of these individuals had been previously arrested, and the methods employed were absurd and repugnant, and not conspicuously efficient. Alphonse Bertillon's great merit was, first of all, to pose the problem clearly in scientific terms. He very soon realized that it was only by a morphological criterion that an individual could be recognized, and that identity had to be defined as *the general body of morphological characteristics connected with the individual human being, specific to one person and one only.*

Bertillon was quite familiar with these morphological characteristics, but which of them were to be chosen? In fact, as we shall see, there are a great many of them and they differ widely from each other. How were the best among them to be selected?

Naturally, Bertillon's choice fell on those criteria with which he was familiar, those which he had seen used ever since his childhood by his father and grandfather—anthropometric measurements. But not all were suitable for the purpose in view. Measurements of the fleshy parts of the body, such as the chest, the waist, the thickness of arm or thigh, are too much affected by physiological or pathological variations due to diet or disease. The first necessity, therefore, was to determine the rules to which measurements should conform in order to make identification possible.

Criteria of Identification

The first criterion must obviously be to satisfy the fundamental condition of morphological identification—specificity. The observed characteristic, whether an anthropometric measurement or any other characteristic, must be specific to one person and one only. Where a measurement is concerned, that measurement must vary sufficiently from one person to another, and not in a systematic but a haphazard way. This condition is so important that it will in fact determine the final choice.

But it is not the only condition. The morphological characteristic selected must remain invariable through time, that is to say, remain constant in the same individual throughout his life, and even, as we shall see, for some time after his death. A further requirement is that the various circumstances of life should not change—and more especially that wounds and illnesses should not modify—the characteristic to any extent.

The selected characteristic must also be easily identifiable in the individual, whether living or dead, though this is a less important condition. We shall

see later that some characteristics duly satisfy the first two criteria but can be recorded only by complicated and sometimes expensive methods. In such cases, preference will be given to the simplest and most generally applicable techniques.

But the accumulation of descriptive data is not enough to solve the problem of identification. While in some cases it may be sufficient to assemble such data in any order, because the choice to be made later will be limited to a few individuals, this is not so most of the time. In order to trace an individual whose description is available from a collection of records covering hundreds of thousands or even millions of individuals, it is imperative that such data should be easily classifiable in some simple way, so that tracing may be both easy and quick.

It is altogether exceptional for one single morphological characteristic to satisfy all these requirements. But a group of characteristics may satisfy them in an adequate degree, and that is precisely the case with anthropometric measurements.

The Bertillon System—Bone Measurements

As we have seen, Bertillon chose as identifying characteristics the measurements of the human body with which he was familiar. But he soon saw that it was necessary to make a selection among them, and that on that selection the value of his system depended. From 1878 to 1882, at the cost of considerable work, the details of which he unfortunately did not publish, he compared countless measurements, drawing up statistics of their variations in different individuals, establishing the frequency curves of these measurements as his father and grandfather had done, calculating the frequency of each measurement in a given population.

He quickly perceived that no single anthropological measurement satisfied the criteria for correct identification. Only the bone measurements were sufficiently stable, at any rate in adults; variations in them during growth did not seem to him sufficient to justify rejecting them, since the number of juvenile offenders was small as compared with that of offenders as a whole. Of these bone measurements he chose only those which can easily be taken from the living individual, because they relate to parts of the body where the skeleton is covered only by a fatty panniculus, for example, the olecranon and the calcaneum, the fingers and finger-joints, the cheek bones and skull bones. Then by comparing the statistics and frequency curves for each, he eliminated all those which seemed to him to be correlated, that is to say, whose values varied in parallel fashion.

In this way he managed to select a few bone measurements—length of the middle finger, length from elbow to finger-tip, length of the foot, length and breadth of the skull, etc.—each varying independently of all the rest and

capable of being taken and correctly reproduced for an individual, whether living or dead, with a suitable degree of precision. Of course, none of these measurements, by itself, was sufficient for the identification of an individual, but when brought together on a record card they provided an accurate description for identification purposes.

One problem still remained to be solved: the classification of the descriptive records. To bring together a series of cards each recording the measurements of a given individual is not in itself enough; it must also be possible to locate the card for the individual you seek to identify quickly and accurately.

Bertillon's statistical researches had enabled him to discover the frequency of each bone measurement for any given thousand individuals; this followed the probability curve with which all statisticians and biologists are familiar. It then occurred to him to separate each of these curves into three parts, in such a way that each part contained about the same number of individuals. Thus, the length of the head was divided into three groups, short, medium and long. In this way he obtained an initial sub-division. The head width supplied him with a second, the length of the middle finger with a third, and so on. Thus, when working on 100,000 cards, the head lengths provided three groups each containing about 30,000 cards; the head widths sub-divided the 30,000 cards into three groups of 10,000, the bizygomatic diameter, into three groups of 3,000, the left middle finger lengths supplied three groups of 1,000, etc. Finally, all that was left was a few cards in a particular box, among which was to be found the wanted person.

The imperfections of bone measurements, however, made it impossible to go further; not only were they valueless in the case of young people who had not yet finished growing, but their variations, because of the inevitable errors of measurement, made a final selection from a small number of cards in a large collection of records difficult. Indeed, it was quite possible to find two individuals having exactly the same measurements within the usual margin of error, and consequently indistinguishable from each other by this method alone.

Bertillon was not unaware of these shortcomings of bone measurements; but he had noticed, in the course of the countless physical examinations he had carried out, that there were very few people without some distinguishing marks such as warts, scars, birth-marks, tattooing, etc. If it were possible to define their shape, size and position exactly, these personal distinguishing marks would allow of supplementing the bone description by supplying a specificity which it lacked.

Bertillon therefore drew up a code of distinguishing marks likely to be found on the face, hands, forearms, bust, etc. He divided the body into several sections and, in the case of each distinguishing mark, defined its nature, shape, size, direction and position. Thus, a scar on the hand might be defined as a curved scar with concave side uppermost, 2.5 cm long, set

obliquely inwards, 4 cm. above the first point of the left forefinger, on the back of the hand. Each of these indications increases the descriptive value of the distinguishing mark by a coefficient which may be high. The terms used for such a description were reduced to an abbreviated code by which the foregoing indications could be summarized in one line.

Supplemented in this way by distinguishing marks, the bone measurements enabled Bertillon to record on his card-indexes several hundreds of thousands of descriptions, with the success we know. The efficiency of his method was admittedly restricted by the shortcomings to which we have drawn attention, but it nevertheless rendered the services that its inventor expected of it. To increase its scope, he added photography to bone measurements and distinguishing marks, together with a detailed description of the face.

Photography and Identity

It might seem surprising that, among the means for determining identity, we should not yet have referred to that which has the appearance of being the most accurate—photography. Surely nothing could be superior to an exact reproduction of the face in all its aspects. A photographic portrait should, it might be thought, be the most reliable documentary evidence of identity.

That, indeed, was the assumption of its first users. From the very moment that Niepce and Daguerre made their discovery, magistrates and police realized how useful it could be to them. On 4 December 1854, Captain L. W. Lees, of the San Francisco Police, started photographing criminals, and in the same year a felon in the Grand Duchy of Baden was identified by the examining magistrate of Lausanne through his daguerreotype which had been forwarded to the police of all the Swiss cantons and adjacent countries.

Bertillon did not neglect this method. Like his predecessors he sought to make use of it for his records. But he quickly realized that it could be of little use to him, though it might help if it were supplemented by a morphological description of the face, carried out systematically in accordance with precise rules. This was the origin of the police description or *portrait parlé* (visual identification).

How are we to explain the failure of the photograph as evidence of identity?

Experience has shown that as a description of the sitter a portrait photograph, even one taken in the best conditions, is nearly always worthless unless the observer has been specially trained to read it.

To recognize a person simply by means of his photograph, or to identify him by means of two photographic portraits, is not in fact such a simple operation as might at first be thought. We often find that we fail to recognize somebody by his photograph, or we identify him with the portrait of someone else. Neither the physiognomical likeness between two individuals, nor the unlikeness between two photographs taken

of the same individual at a fairly long interval can be checked by a more or less instantaneous general impression, but only by an analytical comparison of the facial lineaments.[1]

The entry headed 'description', unfortunately still used on most identity cards, is therefore worthless. Our eye takes in only the general features of a face, which are common to most individuals; unless it has been trained to consider them systematically, it fails to observe all the characteristic details. We must therefore know in advance the facial characteristics which should be looked for and the terms to be used in order to bring out their importance.

Let us consider the different facial features separately one after the other. In each we shall note the hue, the shape of the lines, the slopes and size. There are well-defined terms for each of these four categories; for example, we shall refer to the shape of the lines as rectilinear, hollow (for concave), arched (for convex), aquiline, sinuous or curved. Similarly the slopes will be defined by such terms as vertical, horizontal, oblique, prominent or receding. Lastly, the size will be classified as small, medium or large, using intermediate or extreme terms where necessary.

Proceeding thus systematically with each feature in turn—eyebrows, forehead, nose, eyes, lips, right ear, chin and head—and adding as ancillary characteristics the colour of the eyes, complexion, general shape of the face, wrinkles and even the general appearance, Bertillon produced a descriptive record of such precision that by means of it we can identify with a high degree of accuracy anyone of whom we have such a description, even if we have never seen him.

Thenceforward, it was easy to make the photographic likeness a more efficient instrument for establishing identity. All that was necessary was that the photograph should be taken (a) in adequate conditions as to sharpness and (b) with a measurements gauge or on a known scale of enlargement. This is what Bertillon did. Thus anthropometric photography came into being, profile and full face being taken so that all the data contained in the 'description' would be found in the picture. The anthropometric record was completed by a photograph taken in this manner, which was not only a most useful adjunct in establishing identification, but also afforded the possibility of detecting in it the above-mentioned data. In the mind of its creator, the principal object of the *portrait parlé* was to enable the police to identify a person they were looking for among a crowd, even without the aid of his photograph. This object was fully attained, and even today there is nothing to replace the *portrait parlé*.

A photograph, provided it is taken in the conditions required for the purposes of police description, is therefore an excellent instrument for establishing identity. Why, therefore, are not photographic records set up in which

1. C. Sannié and B. Guérin, *Eléments de police scientifique*, Paris, 1938, Vol. II, p. 6.

photographs would be classified in accordance with the rules used for the police description, thus replacing the various other methods?

The reason is that all the many attempts at such a classification have failed. As soon as photography became a regular police practice in all countries such records were established, in the hope of detecting habitual offenders in this way. With the aid of his albums, in which the portraits were classified by the shape of the nose seen in profile and the lobe of the ear, Bertillon himself tried to arrange in series a certain number of individuals wanted by the police. Ingenious as his system was, he was obliged to drop it, since it was impossible to keep the records up to date and they were not really very useful.

It cannot however be repeated too often that identification by means of a photograph is only reliable if the portrait has not been touched up, has been taken in accordance with the requirements of anthropometric photography, and is sharp enough to bring out the various items in the police description. Most photographs on identity cards or passports do not satisfy these requirements, and their value for identification purposes is nil. A vague resemblance, or the presence or absence of a beard or moustache, are enough to cause a mistake in identity.

Nor should much importance be attached to the robot-portraits that have recently come into vogue in certain police circles for identifying individuals wanted by the police, whose physical appearance has been reconstructed from evidence supplied by witnesses. Only those completely familiar with Bertillon's *portrait parlé* would be able to give a sufficiently accurate description to make sure that the identification was correct. Statements by witnesses afford only very general indications and can never be accepted as sufficient proof of identity. Moreover, this method is only used by the police as a guide, in order to obtain information they can use later in their inquiries.

One point not to be forgotten is that facial details can be altered out of all recognition by plastic surgery, and that criminals, especially international criminals, have often had resort to it. For instance, between 1946 and 1952, the International Criminal Police Commission was concerned, in conjunction with the French, German and Belgian police, with the case of an international thief who underwent an operation to turn his aquiline nose into a straight one. A *portrait parlé* and photograph can therefore only be regarded as a convenient means of identification. They are not completely reliable. We must always remember to find out whether a recent scar may not be the explanation of a change in one feature of the face.

Lastly, a photograph can always be faked and, if open to suspicion, can never be accepted as conclusive proof.

Fingerprints

We are all familiar with those more or less incurved furrows which each of us has on the palms of our hands and soles of our feet, and the use made of them in criminal investigation has often been described. They are formed by the epidermal ridges corresponding to the dermal papillae, arranged in regular rows which constitute the finger patterns. Malpighi (1686) was the first to study their anatomy, and the first pattern of a fingerprint is found in the *Anatomia Humani Corporis* by Govard Bidloo, published in 1685 at Amsterdam and reissued in 1728 at Utrecht. An excellent historical account has recently appeared in a book by Castellanos.[1]

The first systematic study of fingerprints is contained in a treatise by Purkinje (1823), where a detailed description is given of the different forms. This study was taken up and developed by the anatomist Huschke and by Alix, a pupil of Gratiolet, member of the Anthropological Society of Paris.

All these authors consider the papillary ridges from a purely anatomical standpoint. Sir William Herschell was the first to consider using them as an identification mark, by having the fingerprints of Hindu notables affixed to their pension certificates. He noted that in no case did the marks undergo any change, and in 1877 he suggested, though unsuccessfully, that they be used for the purposes of criminal investigation.

In 1878 Faulds, in Japan, took up the question and brought out a classification of fingerprint types. On 17 February 1880 he wrote to Darwin communicating the results of his researches. Darwin, who was then an old man living in retirement, advised him to get in touch with Francis Galton as being the man best qualified to take up the matter.

Galton, in two reports written between 1889 and 1891, carried out a scientific and methodical study of finger patterns and established a system for classifying and identifying individuals by means of their fingerprints. He showed that the finger pattern possessed to an immeasurably greater degree than any other morphological characteristic the qualities of invariability, permanency, diversity, and facility for recording and classifying, these being the four indispensable criteria for ascertaining a human being's identity.

Following upon Galton's investigations, all concerned with the problem of identification have adopted fingerprints as the fundamental test. We may cite among them Vucetich, in the Argentine, who in 1891 originated the classification system still used in Latin America, and Henry who developed the Anglo-Saxon system. Bertillon alone adhered to his anthropometric method, but was compelled by force of circumstances to include fingerprints in his records, though in the form of an ancillary subdivision.

Faulds and above all Galton had already drawn attention to the permanence

1. I. Castellanos, *Dermopapiloscopia clinica*, La Havana, 1953, 2 vols.

of fingerprints. All the research carried out during the past seventy years shows that the fingerprints never change throughout life. They first appear in the foetus towards the fourth month of pregnancy and only disappear with the decomposition, not of the epidermis, but of the derma. Thus the corpses of the drowned have often been identified several weeks after immersion, the dermal papillae being still well preserved in spite of the disappearance of the epidermis.

Nor is it possible to change them at will. Certain criminals have tried to get rid of them by replacing them with scars. But the mere fact of having scars where the marks of the fingers should be is suspicious, and the pattern of such scars is, of course, in itself sufficiently specific to take the place of the actual fingerprints.

Sometimes, however, the fingerprints change and become deformed so that identification is no longer possible. This happens in the case of wounds caused by cuts, burns or lacerations sufficiently deep to affect the derma. In these cases the fingerprint suffers a local change and is replaced by a scar at the particular spot affected. But everything outside the area of the wound remains intact and suffices to make identification possible.

The position is not, however, the same in the case of certain diseases, especially those where trophic disorders affect the extremities, and again in that of lesions of the radial and ulnar nerves (Cestan, Descomps and Euzières, 1916). To Professor Leonidio Ribeiro, of Rio de Janeiro, is due the credit for having drawn attention to the changes which occur in fingerprints, especially in cases of leprosy.[1] He showed, moreover, that if the patient improves, the finger pattern is built up again exactly as it was before. The same is true in many other cases, such as, scleroderma, X-ray dermatitis, and certain forms of poisoning. Readers interested in this subject will find a very clear account in Ribeiro's book and in Castellanos' important and more recent publication already mentioned.

Another advantage of papillary patterns for identification purposes is their immense variety, which no other morphological characteristic possesses to the same extent. Many investigators, among them Bertillon himself, have sought in vain for two identical fingerprints. On the contrary, all the research undertaken throughout the world on hundreds of millions of fingerprints has shown with absolute certainty that no two finger patterns are absolutely identical.

This diversity is explained by the morphology of the fingerprint, which is formed by ridges that stop short, break up, divide and branch off. Each irregularity in these ridges occupies a definite position in the pattern in relation to the rest, so that all we have to do is to pick out a few of these irregularities in order to prove that the fingerprint is unquestionably that of

1. Leonidio Ribeiro, *Pathologie des empreintes digitales*, Paris, 1946.

the person we are seeking to identify. It has been confirmed by both experiment and calculation (Balthazard, Sannié and Amy) that a limited number of points is sufficient for absolute certainty. All dactyloscopists now agree that from 12 to 15 identical points between two papillary marks are sufficient proof that they belong to the same finger.

The mark made by the tip of the finger contains more than a hundred of these informative points, arranged in no particular order. Thus, only one papillary mark is necessary for an individual's formal identification, even if it is very incomplete and fragmentary. We have only to pick out the indispensable characteristic points, but we can then be absolutely sure of the result.[1]

Fingerprints are moreover very easy not only to record but also to classify. All that is needed is a metal plate, a gelatine inking roller and a tube of ink. Two main systems of classification are in use, one in the Anglo-Saxon countries, the other in the Latin countries. Both systems are based on the general shape of the pattern which can be reduced to a limited number of types, generally four or five. In the French system (also used in other Latin countries in Europe and in South America), each of a person's 10 fingers is given a number corresponding to the type of his fingerprint, the number thus obtained making a large selection possible; when a card index becomes too full it is subdivided by counting the ridges in the pattern on each finger in accordance with certain very precise rules.

Whatever method is chosen, it is possible to assemble many millions of individuals on a single card index and to identify among this mass of cards the person wanted. *But the prints of all 10 fingers are necessary,* since only with them can we draw up the requisite dactyloscopic formula by which the required card can be found in the files.

This difference between the significance of a fingerprint, or even part of a fingerprint, as a clue, and the identification value of the 10 fingerprints is basic, but it is too often overlooked. How often have we been asked to find a person in our records with the aid of a more or less fragmentary print of one finger only! But that is quite impossible.

Other Morphological Criteria

Bone measurements, special marks, the police description and anthropometric photography, fingerprints—these are not the only criteria of morphological identification. Many other physical characteristics have been suggested, the value of which varies considerably.

Some are connected with the Bertillon system; thus Frigerio's otometry and Fresneda's[2] method based on the shape of the ear seen from behind,

1. C. Sannié, *La recherche scientifique du criminel,* Paris, 1954, p. 38.
2. D. M. F. Fresneda, *Investigación,* Sept. 1954, p. 58.

are merely developments of it. Other aids recommended are occupational markings on the hands, which unfortunately are evanescent, the topography of the veins on the back of the hand (Tomasio), the shape of the lips, and even, for identifying thoroughbred stallions, the pattern on the muzzle. We find on the muzzle of cattle, horses and dogs delicate furrows which resemble papillary ridges, and which like them are absolutely reliable for identification purposes.

In the same way the white of the eye shows a network of blood vessels of which the pattern varies in one way or another, and which can be used as a characteristic. They can be seen with the ophthalmoscope and photographed, and it is impossible for anyone to change them (Capdeville).

Radiography was thought of a long time ago. In 1889 Levinsohn, in Berlin, tried to develop a system of radiological anthropology. Later, Calico, and afterwards Luis Belclos (1933), suggested radiography of the finger-joints. Ercole Bocchi experimented with radiography of the spinal cord[1] and attempted a classification of the shapes so observed. More recently, E. Moniz,[2] has tried to systematize craniofacial radiography, the shape of the skull and face being very characteristic and showing notable individual variations.

In point of fact, the only significant anatomical characteristic is the bucco-dentary system.

It is not possible to quote all the writers who have studied the problem of identification by the teeth. Already in the last century corpses were identified by this means, and Dr. Oscar Almoedo's treatise on a corpse supposed to be that of the dauphin, Louis XVII, who died in the Temple, is still famous. In 1883, Dr. Grady, medical officer at the Naval College of Annapolis, U.S.A., brought out his first published work, and in 1915 he started a card-index of the pupils at the Academy. We may also mention, in Latin America, the names of Lopez de León, Luis Silva, Carrea, Repullini and Gramajo, Santos; in the United States, Taylor; in France, Jean Morisot's treatise (1925) and the researches of Budin, Filderman, Sapet, and more recently those of Bonnafoux, which actually resulted in the tabling of a motion in the French parliament.

Identification by the teeth can claim some resounding successes, for example in the case of the Bazar de la Charité fire in 1897, and the fires at the Paris Opéra Comique and the Ring Theatre in Vienna. The cases of the Marquis de Morès, the Prince Imperial, and Becker, secretary to the German Legation in Chile, this last solved by Dr. Valenzuala Bastorrica, are classic examples to this day. In these cases all other means of identification were found worthless, and the remains could only be identified by the teeth.

1. E. Bocchi, 'A identificaçao do adulte pelo esqueleto craneo', *Minerva medico-legale*, 1950, Vol. 70, No. 5, p. 170.
2. E. Moniz, Jr, *Revista de Identificaçao e Ciencias Conexas*, June 1951, No. 13, p. 163.

When the other morphological criteria have disappeared, the teeth, which are far more difficult to destroy, may be used as the means of identification. This is the regular practice in all disasters due to fire or water (fires, aeroplane accidents, shipwrecks, drowning). The epidermis, the derma, frequently too the muscular tissues, have disappeared or are putrescent. All that is left is the skeleton, and even that is not always intact. The brain-pan is, however, the strongest portion of the human frame, and the teeth, being protected by the maxillaries, are often found undamaged with all their defects, stoppings and artificial additions. The dentist whose patient the victim was can recognize his own work and thus identify the person to whom the teeth belong.

CRIMINAL IDENTIFICATION

All civilized societies have sought means of identifying, among the mass of their citizens, individuals already convicted of a crime and therefore to be regarded as potentially dangerous. We find this preoccupation expressed in the most ancient legal systems, in those of India, Rome and Greece, then in Europe, and lastly in America. They all make provision for the branding of the criminal with a mark that will enable him to be identified.

Among some primitive peoples punishment for crime involved mutilation, which thus served as a distinguishing mark. In Assyria, a thief's right hand was cut off. Again, in Russia, the law provided for certain forms of mutilation—cutting off the nose or the ears—which in themselves constituted a brand of infamy. Later, however, the use of patterns or letters became more common.

In India, the laws of Manu prescribed that a device appropriate to the offence should be imprinted on a convict's forehead. In France, the fleur-de-lys was branded by a red-hot iron on the forehead. In 1562 the fleur-de-lys was replaced by the letter V for an ordinary thief, W for an habitual thief, F for forgers. Later, in 1724, galley-slaves had the mark GAL branded with a red-hot iron on the shoulder.

Branding was abolished in France after the 1789 Revolution, together with certain penalties which were felt to be unduly barbarous, such as torture by the wheel and fire. But it was reintroduced by a law of Floréal, Year X, and was only finally abolished in 1821. In France all such marks of infamy were finally done away with in 1832.

A similar evolution took place in England, where branding was used from the reign of Edward VI until its abolition in 1829, the practice being accompanied by a special ceremony.

Such marks, being applied in the manner described, could have only a very relative value as a clue to identity. They merely indicated that the person branded had committed a crime once upon a time, but they gave no

information whatever as to the individual himself. With the exception of the W used in France for habitual offenders, they afforded absolutely no indication as to whether the delinquent had been convicted more than once.

In 1831 a recommendation was sent to governors of prisons to have a record made of tattooings or similar markings on the prisoners' bodies, since this would do away with the need for branding.

After branding had been abolished there was no longer any means of recognizing habitual offenders, and to remedy this omission the police had to resign themselves to the use of methods which did them little credit. Thus, in a cell housing a prisoner whose judicial past the police were anxious to ascertain they placed another prisoner who was in their confidence—a 'coppers' nark'—with instructions to make him talk and reveal his previous crimes. Or, again, a reward would be offered to police inspectors who visited the cells daily for every identification they succeeded in making.

In 1885, the French parliament, alarmed at the existence of a criminal population which was mainly recruited among escaped prisoners and ex-convicts, tightened up the laws dealing with habitual offenders.

We find the same tendency to a greater or smaller degree in all legal systems. Any civilized society is, of course, in duty bound to protect itself against habitual offenders, but it is even more important for it to try and eliminate from the body politic all those who have made a habit of crime. And it may be that with the present trend in criminology, knowledge of an individual's criminal record, and consequently knowledge of the offender's criminal identity, have become still more necessary. How can we decide whether he can be reformed or is incorrigible if we know nothing at all about his past history? Without such data no scheme could be worked out for the reformation of the criminal or for placing him on probation.

We have already shown how Bertillon solved the problem by introducing his anthropometric method. He invented this system with the idea of applying it to prisoners undergoing detention, and its success was proof of the very great progress it represented throughout the whole realm of criminology. Bertillon's system has now been replaced by fingerprinting, and every organized country has a criminal identification service.

In France, a law of 1943 provides that, if the magistrate thinks it necessary to establish or confirm a person's identity, such person must allow his fingerprints to be taken and they are then filed. His morphological identity is then definitely known and fixed, quite apart from his name and civil status.

CIVIL IDENTITY

It is difficult to explain the utter failure of the legal mind to take any interest in the question of identity. For the lawyer it is purely a matter of civil status,

that is, the individual's name, parentage and birthplace. The only proofs of identity which he seemingly regards as having any value are a person's certificates of birth, marriage and death, and the signature, the chief advantage of which is that it affords an abundant harvest for graphologists.

In France, for instance, a very complete general directive was recently issued with detailed instructions on the keeping of the registers and the filing of the various documents,[1] but containing not a single reference to morphological identity. For those who drafted it, identity is sufficiently established by the civil status record and the accompanying supporting documents.

Legally, the recognized civil status documents are the birth, marriage or death certificate or some civil status document in lieu, for example, the family registration booklet (*livret de famille*), passport, and the various identity cards.

There is no need to demonstrate the inadequacy of a signature as a proof of identity. Those jurists who regard it as reliable seem to look on it as a kind of personal seal for which there is no substitute. A decision given by the Cour de Cassation[2] (15 May 1934) refused to recognize the possibility of its replacement by a fingerprint. The Court regarded the latter as a 'mere mark'!

In France, a change of name and identity is not an offence. Anyone can, as the fancy takes him, declare an imaginary civil status without incurring any legal sanction, provided he does not assume the identity of another person. A recent Order (2 November 1945) introduces penalties for the use of an imaginary identity by a foreigner. Although this represents some progress towards the safeguarding of identity, much remains to be done, and nothing really constructive will emerge until the morphological tests are made the basis of identification. They are the only reliable criteria.

In point of fact, there are no civil status documents by which identity can be proved. Nothing is easier than to falsify them or obtain a fake, and all magistrates and police inspectors know what care is needed in accepting them. Even identity cards, which would seem to be the safest, are in reality worthless as evidence.

How is this to be explained, seeing that in Paris the identity card issued by the Préfecture de Police contains not only the entries as to civil status, but also a description and a fingerprint, and that a duplicate is kept in a special file in the Central Office?

The truth is that, in France at any rate, all identity documents were invented by officials with no knowledge of identification problems. The best example is, in fact, the identity card issued in Paris, or the new French national identity card.

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1. *Journal officiel*, 22 September 1955.
2. The supreme court of appeal in France.

What is the use of amassing the duplicates of these identity cards in a card-index if the only clues for looking up a card are the name and civil status, that is, those very characteristics which it is desired to safeguard and which anyone can change or modify at will?

But, it will be objected, there is a fingerprint affixed to the identity card. Will not that serve to confirm or reveal a man's identity, if the name and civil status do not suffice?

True, the fingerprint is proof of identity, that is to say, with one of these cards in our hand we can state positively that the fingerprint on it is definitely that of the person whose photograph is affixed to the card. But the fingerprint does not help us—and this is the essential point—to look up the duplicate card in the card-index. For that we must have, as has already been stated, the fingerprints of all 10 fingers. Without these, classification and consequently a search become impossible. That is why the identity card-indexes kept in France, and in most other countries, are a very imperfect safeguard in the matter of identity.

Whereas for the last 60 years examining magistrates and the police have recognized the importance of morphological tests as evidence of identity and as a means of avoiding judicial errors, registry office officials and the administrative departments are still without any knowledge of them. And yet what is true in criminology is equally applicable in the social and civil spheres, and there can be no doubt that one day the same solutions will be used in matters of civil identity.

For a good many years some of the Latin countries, for example, most of the South American States and Portugal, have been moving along these lines. They have set on foot a national card-index, in which either the whole population is recorded, or else certain categories, such as foreigners. This card-index, which is modelled on criminological card-indexes, makes use of the 10 fingerprints for looking up cards; it thus links up, beyond all possibility of error, a civil status record with a morphological characteristic, namely the fingerprints.

There is no other means of making identification certain. It is most likely that one day this will be a universally acknowledged truth and that civil dactyloscopic records will be as widely used as criminal records are at present.

THE SOCIAL ROLE OF CIVIL IDENTIFICATION

What are the advantages that will accrue to the individual and society from a national card-index system of identification?

They will accrue to every one the day that he or she is born. Although child substitution in maternity clinics is very rare, it raises a serious moral

problem, and much work has been done on ways and means of avoiding it. Here again the only effective method is to have a fingerprint record. But with a new-born infant there are certain difficulties; the papillary ridges are not sufficiently prominent, and above all it is very difficult to take the fingerprints of a child who keeps its hand clenched. So it has been suggested that prints should be taken of the soles of the feet, as these can be more easily inked and printed on a card.

Both methods are most effective. Large numbers of impressions are not wanted, the point being to make sure of the infant's identity for a certain period, not more than one or two years. The child's dactyloscopic record can, if necessary, be made out later.

New-born infants are not the only children to benefit from the fingerprint method of identification. There is the curious case of the mother who was obliged to apply to the head of the Identification Bureau at Evansville, Indiana, so as to be able to distinguish between her twin girls. They were so alike that she was never sure which was which; once their fingerprints had been taken and recorded, there was no possibility of error.

Fingerprint identification is obviously to the advantage of every citizen. We all know how strict are the laws in the matter of missing persons and how serious the difficulties with which a family is faced when the father has disappeared leaving no trace, it may be in an air accident or shipwreck or at the wars; or he may have gone off on an escapade or yielded to a pathological impulse; or perhaps he has been accidentally drowned and later his corpse lies in the mortuary unrecognized. In every country thousands of persons disappear each year and leave no trace; among them there are always many who have deserted their family and changed their civil status in order to start a new life. The problem would be greatly simplified if there were a national civil identification service which, except when the body was not recovered or had been completely destroyed, could verify the identity of an unknown corpse and thus save families all the hardships resulting from the laws on missing persons.

An account of cases like these was published by J. E. Hoover, Director of the Federal Bureau of Investigation in the United States, with the aid of his identification branch which keeps a large body of civil as well as criminal records. He describes cases in which a mother found her long-lost son, and a man who had lost his memory and an unknown corpse were identified, etc.[1]

We have had personal experience of cases of usurpation of civil status. If a criminal steals your identity documents, and is then condemned by default under your name, it is very difficult for you to prove your *bona fides* without submitting to a searching inquiry and all kinds of difficulties. The consequences can be extremely serious and without redress, and we have often

1. J. E. Hoover, 'Dactyloscopy's Humanitarian Role', *International Criminal Police Review*, No. 34, January 1950.

been visited by people who, as a result of such disagreeable experiences, came of their own accord to have their fingerprints recorded in our files. They then felt they were absolutely safe.

But the main benefit that would accrue to each of us from the establishment of a civil identification service would be an immense simplification of all administrative formalities. As soon as each citizen's identity was established, beyond all possibility of error, by a national card-index the latter could be used for the issue of a national identity card, which could be checked at any time and would take the place of all identity documents now in use.

Society would also stand to benefit by such a card-index. Apart from its obligation to protect the new-born infant—a responsibility in which the community comes next to the child's mother—it would also be able to simplify a host of administrative records. Many difficult problems would also be simplified by using fingerprints. Pensions frauds and desertions from the colours could be avoided, and it would be far easier to check passports and supervise aliens if there were a national register to refer to.

One has only to think of the millions of stateless persons who have wandered up and down the world over the past 20 years, of the hundreds of thousands of children who have been cut off from their parents by the tragic events of these last few decades, and have in many cases lost them with no hope of seeing them again, to realize the immense services that national identification card-indexes could have rendered. The question of personal identity raises social and humanitarian problems which no well-organized society has the right to neglect.

LEAF PROTEIN — FOOD OF THE FUTURE

by

RALPH WHITLOCK

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With the present world population estimated at well over two and a half thousand million and expanding at an ever-increasing rate, the old Malthusian nightmare of a world whose inhabitants had outgrown the food supply threatens more and more to become a reality.

It is not simply a problem of making existing surpluses available. Although temporary surpluses of certain foodstuffs do occur from time to time, there is an over-all shortage of food; undernourishment is the common lot of more than half of mankind. Nor is there likely to be a change in this situation in the near future.

The days of the nineteenth century, when vast new territories were becoming available for exploitation by agriculture, have gone for ever. No such virgin territories of any size now remain. Today, it is a matter of making better use of land already under cultivation, and of extending the food-producing area by bringing into cultivation land which would have been considered unsuitable by our ancestors.

In recent years, men have been appraising the deserts of Africa, Asia and Australia, the sub-Arctic plains of Russia and Canada, and the tropical forests and scrubland of Africa and South America. Yet although many ambitious schemes have been and will be launched, the developments of such marginal regions for food production is both expensive and hazardous—as the British ground-nut scheme in Tanganyika has shown. Nor is it encouraging to be confronted with such facts as the low standard of living of the inhabitants of the Amazon basin, which is theoretically one of the richest regions on earth, and the difficulty experienced by Australia, that most thinly-populated of all continents, in feeding the swollen population of its cities.

In the circumstances, there can be no slackening in our efforts to increase food supplies, however limited the results of these efforts. Side by side with the encouragement of more efficient agriculture on land already under cultivation, and with the development of new marginal areas, goes investigation into new sources of supply. Increasing interest is being taken in the world's fisheries, particularly in remoter waters such as the Behring Sea and off the

west coast of South America. Plankton has been advocated as a nourishing food, both for human beings and for farm livestock, the latter being the likelier to prove a practical proposition. A green alga, *Chlorella,* has produced by photosynthesis, under experimental conditions, high yields of a protein-rich food, though the problems of large-scale production have yet to be solved. Much publicity has also been given to the development of pond cultures, especially in the Far East. The fishponds of Hongkong, for instance, produce fish at the rate of 3,000 lb per acre.

Now, a new source of food supply makes its appearance: after years of experiment, success has been achieved in the extraction of leaf protein, and a new world of possibilities is thus opened up to us.

THE ADVANTAGES OF LEAF PROTEIN

All food comes primarily from plants, but complications arise from the inability of the human stomach to digest much of it in its vegetable form. Though we can eat a wide range of plants, from wheat to lettuces, those that are digestible by man constitute a very small minority in comparison with those that are inedible for us. Unfortunately, some of the most abundant plants, such as the grasses, fall into the latter category. So we have to employ 'middlemen'—the farm livestock—whose function it is to digest the vegetable matters which are beyond the capacity of our own stomachs, and to transform them into foods suitable for man.

Now, if this intermediary process could be eliminated, the implications would be enormous. In theory, the colossal livestock population of the world's farms would become redundant, and farmers could concentrate entirely on growing crops.

However, this is a theoretical pattern which is not likely to be adopted in the near future. For although the extracted protein, when refined, is easily digestible by human beings, in its cruder form it is an ideal animal food; and it therefore seems probable that it will bring about an increase rather than a decrease in the farm livestock population, at least in the earlier stages of development.

As an animal feeding-stuff it has three main advantages:

1. It can provide for pigs and poultry the protein required in a balanced ration, and can thus make the farmer independent of purchased proteins in the form of fish meal or meat meal. He can grow a completely balanced ration for his livestock on his own fields more cheaply than he can buy it.
2. It can provide a satisfactory method of storing protein-rich plant foods, gathered at the time of their greatest abundance, against a time of scarcity. Thus, in the northern temperate zone, grass cut at the spring flush may, after processing, be kept for feeding in the winter months. It maintains

almost its full value in the leaf protein extract—certain constituents such as carotene, being preserved much better than they are in dried grass, where they rapidly become a wasting asset.

3. It makes a new selection of farm crops possible. In the past, farmers have had to grow crops which not only had good feeding value but were also palatable, either to human beings or to animals. There was no advantage in growing a protein-rich crop if neither man nor beast could or would eat it. With leaf protein extracts, the question of palatability does not arise. The extract is of roughly the same quality whatever its source. The only criteria in selecting the plants for processing are protein content and abundance.

Among the best of such plants in the northern hemisphere are lucerne (alfalfa), lupins and grasses; but plants such as nettles (normally regarded as weeds) have a high protein content and are of luxuriant growth, so that they are worthy of consideration as a farm crop. In the tropics, a very wide range of lush vegetation is under consideration and indeed, at the moment, tropical countries are taking much more interest in the development of leaf protein extraction than are most of the temperate ones.

THE PRODUCTION OF LEAF PROTEIN

Interest in the extraction of leaf protein may be traced back to the work of two French chemists, the brothers G. F. and H. M. Rouelle, in the 1760s and 1770s.[1] H. M. Rouelle extracted from hemlock leaves what he called '*la matière glutineuse*', and realized its similarity to animal proteins. Since then, several patents have been taken out to cover various methods of extraction, and research has been going on intensively in recent years in a number of countries, notably the U.S.A., Britain, the Netherlands and Germany.

In Germany, before the second world war, the firm Alexandrawerk was marketing a machine, based on the screw-expeller principle, for extracting juices from sugar beet tops and leaves. A very similar machine has been under experiment in Austria since the war.

Dr. N. W. Pirie,[2] now of Rothamsted Experimental Station in England, in 1940 began large-scale experiments in leaf protein extraction and preparation, using a wide variety of available machines. After a year or so, this

1. 'Observations sur les fécules ou parties vertes des plantes, et sur la matière glutineuse ou vegete animale', *Journal de médecine, chirurgie (et) pharmacie*, 1773.
2. N. W. Pirie, 'Some Practical Aspects of Leaf Protein Manufacture', *Food Manufacture*, 17, 1942; 'Leaf Protein', *Food Manufacture*, 22, 1947; 'Green Leaves as a Source of Protein and Other Nutrients', *Nature*, 149, 1942; 'The Circumvention of Waste', in *Four Thousand Million Mouths*, ed. by F. le Gros Clark and N. W. Pirie, London, 1951.

work was discontinued, but it was resumed after the war and is still proceeding.

R. E. Slade and J. H. Birkinshaw,[1] in Britain, took out a patent in 1939 for extracting protein from grass, chiefly by means of pressing. In 1936, C. Goodall, working mainly on the extraction of vitamins and medicinal constituents from plants, described the extraction of juice from the leaf cells by means of grooved sugar-cane rollers.[2]

The Western Regional Laboratory at Albany, California, carried out experiments in 1947 in extracting protein from lucerne by means of a machine known as the Reitz disintegrator, which apparently combines the properties of a hammer-mill and a centrifuge.[3] Somewhat similar investigations were being made about the same time in various other parts of the United States, and work is presumably still in progress.

In the Netherlands, W. B. Deijs[4] succeeded in 1949 in extracting from grass a juice containing 43 per cent of crude protein by means of a wringer-press.

It is, however, almost impossible to give a complete picture of the progress of experiments in different parts of the world. An increasing number of scientists, in both state and private laboratories, are working in secret on various processes for protein extraction, and the nearer they come to success the greater the secrecy; details of the processes are jealously preserved until the time is deemed ripe for publication. But enough has been said to show that they have reached an advanced stage.

In general, it may be said that the principle behind leaf protein extraction is the release of the protein in the cells by a combination of pressure and abrasion. In later stages, the extracted juice may have to be treated by other processes before being ideal for storage or use. An ordinary kitchen mincing-machine is a reasonably efficient extractor of leaf protein on a small scale, though obviously it becomes less economical as the scale increases. It is interesting to note that pressure and abrasion are precisely the forces used by cattle to extract leaf protein naturally by chewing.

The one notable exception, so far published, to this general principle is that described by J. T. Sullivan,[5] who first dried and ground the leaves, and

1. R. E. Slade and J. H. Birkinshaw, 'Improvements in or relating to the Utilization of Grass and Other Green Crops', Brit. Pat. 511525 (1939); R. E. Slade, Branscombe and J. C. McGowan, 'Protein Extraction', *Chemical Industries*, 23, 1945.
2. C. Goodall, 'Improvements relating to the Treatment of Grass and Other Vegetable Substances', Brit. Pat. 457789 (1936).
3. E. M. Bickoff, A. Bevenue and K. T. Williams, 'Alfalfa has a Promising Chemurgic Future', *Chemurgic Digest*, 6, 1947.
4. W. B. Deijs, *Experiments in the Pressing of Grass*, Central Institute of Agricultural Research, Wageningen, Holland, Stencil No. 413, January 1949; *Results of Experiments in the Pressing of Grass with the Aid of a Wringer Press*, Central Institute of Agricultural Research, Stencil No. 1, 1950; *Experiments in the Pressing of Silo Grass and Beet Leaves*, Central Institute of Agricultural Research, Stencil No. 1068, 1951; W. B. Deijs and J. J. I. Sprenger, *The Production of Protein from Green Fodder Plants*, Central Institute of Agricultural Research, Stencil No. 1, 1953.
5. J. T. Sullivan, 'Protein Concentrates from Grasses', *Science*, 98, 1943; 'High Protein Concentrates can be obtained from Grass', *Food Ind.*, 245, 1944.

then extracted the protein from the meal or powder. His product, obtained on a laboratory scale, contained 72 per cent of protein. The process would, however, apparently be prohibitively expensive on a commercial scale.

The first firm to lift the veil from their experiments and to venture on to the market with a commercial machine is a British firm. Their machine, the 'protessor,' was exhibited at the Royal Show in 1955 and is now in limited production. It works on the following lines.

The green plants are first prepared for processing by means of a chopping machine called the 'pre-chopper'. A conveyor then takes this green matter into the main part of the machine—a specially constructed wringer-press in which the material is crushed and pressed simultaneously. The juice runs into a settling tank, in which a sediment of impurities forms on the bottom.

Meantime, the residue of the green matter passes into a washing machine, where it absorbs more water in readiness for a second passage through the protessor. The second extraction of juice joins the first in the settling tank.

The juice, rich in protein, can be used in its liquid form, but in general it is taken a stage further and coagulated, by means of steam, in a second tank. After coagulation, the 'protess', as the extract is called, can be pressed in a cheese-press, from which it emerges as a hard cake, dark greenish in colour. This cake may afterwards be ground into meal, or it can be subjected to various purifying processes, ultimately leaving a colourless, tasteless powder which is largely pure protein.

The actual protein content of the protess naturally varies a good deal with the type, quality and age of the crop from which it is made; and so does the extraction rate. Let us take, for instance, a green crop containing 80 per cent moisture, which means that one ton of the crop will produce about 448 lb of dry matter. This dry matter is composed of fibre and nutrient, according to the state of growth, the time of year and other factors, but usually the rate is approximately 60 per cent fibre to 40 per cent nutrient. Thus one ton of green matter would produce about 180 lb of nutrient, which is here called protess. In general, this protess will contain about 40-50 per cent of protein according to the crop, the season, etc., the remainder consisting of digestible carbohydrates, fats, oil and other foods.

The following table gives actual results obtained from the protessor plant.

Crop	*Dry matter in ton of fresh crop*	*Crude protein in ton of fresh crop*	*Dry matter in protess*	*Crude protein in protess*		*Yield of crude protein extracted from green crop*
	(lb)	(lb)	(lb)	(lb)	%	%
Cocksfoot	635	67	148	28	18.9	41.7
Peas	354	64	134	35	26.2	54.7
Barley I	434	52	120	29	24.2	55.8
Barley II	497	52	152	28	18.4	53.8

In each instance, one ton of fresh crop was used. Two separate crops of barley, taken from different fields and at different stages of growth, were processed to give an idea of the variation that may be expected between two different crops of the same plant.

The results were obtained by putting the green matter through the machines once only. Normal practice is to put it through twice, and this results in the extraction of an additional 50 per cent or more of protess, with a corresponding additional yield of protein. The final percentages of crude protein in the protesses made from these four substances were as follows: cocksfoot, 25 per cent; peas, 34.1 per cent; barley I, 34.7 per cent; barley II, 33.6 per cent.

Comparable results for protesses made from other green crops are: white clover, 38.4 per cent; lucerne, 43.7 per cent; Italian rye-grass, 38.7 per cent; maize, 37.25 per cent; pea-vine waste, 41.1 per cent; nettles, 37.0 per cent; fat hen (goosefoot), 44.0 per cent; sunflower husk, 24.6 per cent.

Another highly relevant point is the percentage of protein in the original green matter which can be extracted by the process. Reverting to the above table, it will be seen that from about 40 to 55 per cent of the protein originally contained in the green matter can be extracted by putting the matter through the machines once only. Even better results have been obtained with two pressings. With lucerne, for example, it is possible thus to extract about 70 per cent of the original crude protein in the green matter. The machines are capable of dealing with fresh green matter at a rate of one ton or more per hour.

THE USES OF LEAF PROTEIN

Though modifications and improvements could doubtless be made to increase these extraction rates, at the moment it is not certain whether this would be desirable. Farmers who have studied the process believe that on a commercial farm it might well be used in conjunction with silage-making. A protessor working alongside a silage clamp could process the green matter as it was brought in. After the extraction of juice, the fibrous residue would still contain anything from 30 to 60 per cent of the original crude protein in the crop, and could be transferred immediately to the silage clamp for mixing with the silage. The mastication process to which this residue had been subjected would help to improve the texture of the silage as a whole, besides enriching it with protein. In brief, the protein extracted in the form of protess might well be considered as a by-product of silage-making, costing very little beyond the running expenses of the machine.

It should be kept in mind that the extracted protein can be used either in liquid or solid form. In the former case, half of the machinery may be dispensed with, for the liquid can be used straight from the settling tank.

This brings us again to the chief advantage of leaf protein extract, which is that, while being rich in protein, it has a low fibre content. Consequently it can easily be digested by non-ruminant animals. If used in liquid form, direct from the settling tanks, it can be mixed with ground barley and similar cereal meals to form a crumbly mash, eminently suitable for pigs and poultry. Experiments are still going on to determine the optimum ration of leaf protein extract when fed in this way, but it is known that it can largely replace fish meal in a balanced ration for such livestock.

However, the main use of the leaf protein extract must be confined to its powder form. The storage problem posed by the liquid extract is obviously a limiting factor. As a powder, however, the protein can be mixed into compound feeding-stuffs in exactly the same way as animal proteins, and it can replace them, at least in part, in rations for any kind of livestock.

The immediate application of the protessor and similar processes is therefore likely to consist in providing an alternative source of protein for the feeding of livestock. It does, in fact, bring within sight that millenial day foreseen by the Prophet Isaiah when 'the lion shall eat straw like the ox'. Any farm equipped to produce leaf protein extract could become almost completely self-supporting in the matter of feeding-stuffs, producing from its own fields a balanced diet for all its livestock.

In practice, however, the future of leaf protein extraction is not likely to lie with the individual farmer. The cost of the machine (at present something over £4,000 for the complete outfit) is such that only the larger farmers in the wealthier countries could afford to install it. On the other hand, the scope offered to co-operatives, feeding-stuff manufacturers, etc., is very wide. Investigations so far undertaken indicate that leaf protein extract can be prepared at perhaps two-thirds of the current price of animal protein, so that an early effect may be a reduction in the price of animal feeding-stuffs, and hence in the price of certain foods for human consumption.

Scope for still further economy lies in the possible use of materials which otherwise would be wasted, such as pea-vine waste and sunflower husks, as well as several luxuriantly growing plants now regarded as weeds, such as nettles and goosefoot. Many other weeds and by-products, such as sugar-beet tops and even potato-haulm, may also be utilized, and the possibilities in tropical countries are immense.

Experiments on a laboratory scale show that potato-haulm is a substance from which leaf protein can be easily extracted. It appears that if the haulm is left on the plant until the time when it just starts to deteriorate, and is then cut, little or no effect is noticeable on the crop of tubers. Any additional use made of the haulm would therefore increase the profit per acre. The wet weight of green matter per acre in potato-haulm is somewhere around 10 tons per acre.

As the amount of crude protein available in potato-haulm is about 1.5 per

cent of the total wet weight, an acre of potato-haulm would yield about 336 lb of crude protein, of which more than half could be extracted by present processes.

A 10-acre crop of potatoes could thus yield 15 cwt leaf protein extract. The cost of extraction amounts to from £15 to £25 per ton, according to the number of hours the machine is used annually. A processing plant situated in a potato-growing district, where it could be used most advantageously, would thus extract 15 cwt of leaf protein at a cost of about £10 to £12. The value of leaf protein at present amounts to some £50 a ton, that is £37 10s. for 15 cwt, which would give about £25 of profit per 10 acres from a by-product which would otherwise be wasted. This profit is well worth considering when we remember that the potato crop in Britain alone covers well over 1,000,000 acres.

Nor is potato-haulm the only waste product that can be used seasonally. In installing a plant, arrangements would have to be made for the bulk of the green matter to be provided by a succession of green crops, such as lucerne, grass and cereals, with potato-haulm filling in a few weeks towards the end of summer. Pea-vines and sundry vegetable waste could similarly be utilized.

In tropical countries, the waste products from various commercial crops nearly all present difficulties. Cotton, sugar-cane, cassava and sisal are all harvested at a time when the leaf growth has passed its prime. However, some of these leaves at their best contain fairly high quantities of protein, particularly cassava. It has been suggested that late manuring with nitrogen could increase the growth and protein content of the foliage of sugar-cane and cassava, and that slightly earlier harvesting might catch this protein at its best without materially altering the value of the rest of the crop. Banana leaves have also been suggested as a possible source of supply, though, so far as is known, no experiments in protein extraction have yet been made with them. Weed growth in tropical lands is also rapid and luxuriant, and might well be harvested as a catch-crop.

Beyond the present stage of converting such vegetable raw material into digestible protein for livestock lie the infinitely more important prospects of using it for human consumption. As we have seen, most of the basic problems are solved. The present protessor machine is perfectly capable of producing from various green matter a meal rich in protein and digestible by human beings. This meal, being tasteless, odourless and colourless, could be used as a basis for an infinite variety of food preparations, from soups to ice-cream and biscuits. Flavour could be added at will.

Moreover, the protessor machine is only a beginning. Its potentialities have by no means been thoroughly explored; nor have those of the protess it produces. Other machines will no doubt be introduced within the next decade or so.

As stated earlier, many teams in several countries are engaged in research on the problem, and everywhere a wide measure of success has been achieved on a laboratory scale. It may be expected that, before long, a variety of leaf protein extraction plants capable of operating on a large scale will be produced, some perhaps similar to the protessor, others based on different principles.

It is not difficult to imagine, in the not too distant future, much of the lavish but at present useless vegetation of the tropical countries being thus forced to yield up its protein to feed the teeming population of these lands. Such a development would prove a powerful new factor in solving the problem of the world's food supply.

BOOKS AND PUBLICATIONS

The Father of Scientific Detection

Henry T. F. Rhodes, *Alphonse Bertillon, Father of Scientific Detection*, published by George G. Harrap, London, 1956, 238 p., illustrated, price 15 s.

The lives of famous men, when not romanticized but described realistically with all their greatness and their misfortunes, often make most interesting reading, and one is frequently struck by how much in their careers appears to have been due to chance.

Had Alphonse Bertillon not been a failure, that is to say, a schoolboy incapable of absorbing what he was taught or of submitting to the necessary discipline of school, had he not failed in all his examinations and reached the age of 20 without acquiring either much general knowledge or any degrees, he would probably be completely unknown to the general public today. Despite the influence of his father and grandfather, he would not, in any case, have been able to realize his long-cherished ambition of becoming a laboratory assistant at the National Museum of Natural History, with an annual salary of 1,200 francs and the hope of possibly one day being made a demonstrator. Modest as this dream was, it was too ambitious for him, since it called for the possession of degrees which the young Alphonse was incapable of obtaining, considering that he did not pass his *baccalauréat* until the age of 20, and even then with some difficulty.

When an undisciplined youngster is expelled from all the schools which have endeavoured, one after the other, to make him mend his ways, when he refuses to assimilate either the rudiments of Latin grammar or the most elementary notions of history and geography, what is there to do, when he comes of age, but to send him abroad? There, he will at least be obliged to speak the language of the foreign country. If, at the same time, he is given no money, the unruly young man will have to cope with the harsh necessities of daily life and show what he is made of.

This exile was Bertillon's first stroke of luck. In those days (1874), it was very unusual for young Frenchmen to leave their country and spend several months or years abroad, even if it were no further away than England. Alphonse Bertillon's stay in that country was to influence him all his life. Not only did he adapt himself to English customs and the English outlook, but he came to like them and ever afterwards showed their influence. At the same time, he learnt to write and speak English fluently, which was later to prove very useful to him.

When recalled to France in 1875 to do his military service, Alphonse Bertillon was sent to Clermont-Ferrand and, for the first time, his family heredity, which was later to play such an important part in his work, began to influence his life.

The French army in those days was very different from modern armies. Courteline's descriptions are only just caricatures; his people are all too often faithful portraits of the officers and non-commissioned officers to be seen at that time, in their thousands, in all the small garrison towns of the country. Even then, of course, there were many exceptions; and fortunately Bertillon happened to strike one of them, for otherwise his natural unruliness might have cost him dear. As it was, his officers realized that this young man had certain very unusual qualities and that the best course was to allow them to develop.

What can a young soldier in a small provincial town do with his spare time? If he spends his leisure attending courses at the faculty of medicine and, above all, in the anatomical theatre, measuring and comparing the length of human bones, he will certainly be thought somewhat eccentric. Yet that is exactly how Bertillon did spend his time, when not on duty, playing over again the games of his whole childhood, for he had been accustomed, from earliest youth, to the conversations and discussions which went on in the family between his father, grandfather and uncles, on statistics, anthropology and anthropometry.

Alphonse's father, Louis-Adolphe Bertillon, had refused to go into the family distilling business, since he wanted to take up medicine, which, in fact, he practised throughout his life. From the beginning of his studies, however, he showed a marked preference for anatomy, and especially for anthropology—a science which was making rapid strides at that time. In particular, he was very much taken with the various ways of applying mathematics to the human frame, described by Quetelet in his *Physique sociale*: from this he learnt that measurements of the human body could be expressed in terms of statistical laws and, from 1846 onwards, he began to apply those laws to certain ethnic groups. He was thus able, thanks to Quetelet's laws and statistical research, to prove that the population of the department of the Doubs fell into two groups, one small in stature, of Celtic origin, and the other large in stature, of Germanic origin.

As a young man, Dr. Bertillon held extremely liberal political opinions and, after the failure of the revolution of 1848, he was imprisoned for no other reason—if reason it could be called—than that his ideas were too advanced. At Sainte-Pélagie, where political prisoners were at that time incarcerated, he was surprised to meet Achille Guillard, a much older man and the author of a *Démographie comparée,* which was published in 1854; Dr. Bertillon had followed a series of lectures on demography given by Guillard and had a great admiration for him.

This encounter had a decisive influence, not only on Louis-Adolphe, but also, at a later date, on his son Alphonse. The friendship struck up during their six months in prison continued after both men had been released. Alone in Paris and very shy, Louis-Adolphe came to regard Guillard's house as a second home, and the two families were very soon united by still closer ties when, in 1850, Dr. Bertillon married Achille Guillard's daughter, who was thus to be the mother of Alphonse.

It was during their time in prison that Guillard and his future son-in-law laid the foundation for the School and Society of Anthropology, which were established in 1859 by Broca, Quatrefages, Achille Guillard and Dr. Bertillon, and were soon to enjoy an international reputation. All Dr. Bertillon's children, including Alphonse, were accustomed to hearing their father, grandfather and all their friends holding lengthy discussions on statistical and anthropological problems and the instruments for measuring the human body; and they very soon learnt to use those instruments.

When he had finished his military service, Alphonse Bertillon went back home and had to be found employment. After an unsuccessful experiment in a bank, which very quickly dismissed the young clerk for his unruly conduct and untidy handwriting, he obtained a post, in desperation, as a clerk at the Paris police headquarters (*Préfecture de Police*), where his father had influential friends.

This was the turning point in Alphonse Bertillon's whole career. His waywardness and lack of general education prevented him from achieving his ambition to undertake scientific research. In order to earn a living, and because he was incapable of doing anything else, he was obliged to accept a penpusher's job at police headquarters and, as luck would have it, found himself in the office responsible for copying out the index cards of the offenders committed to the cells each day; habitual offenders had to be sorted out from the others and, as Bertillon was of an independent disposition and hated routine work, he could not bring himself to accept the stupid procedure of his office and set out to improve it by the only means at his disposal, the only scientific methods within his range of knowledge.

Thus, the science of anthropometry was born. This is not the place to relate its history; in any case, H. T. F. Rhodes devotes many pages to it in his book. A study of its genesis and development shows that it cost Bertillon an amazing amount of effort to work out his methods. Rhodes several times draws attention to one aspect of the latter's personality, namely, that he was a technician far more than a theoretical scientist. In her book on Alphonse, his niece, Suzanne Bertillon, tells us how difficult he found it to prepare the notes or memoranda in which he described his methods, and indeed he wrote extremely little. On the other hand, he was unequalled at perfecting a technique, carrying out repeated tests and measurements and

comparing the results of his experiments. Apart from the invention of his methods of identifying habitual offenders, to which he owes his fame, Alphonse Bertillon made many improvements in the methods and apparatus which he used in his photographic laboratory. For instance, basing his experiments on the work of Colonel Laussedat, one of the pioneers of photogrammetry, he applied this technique to photographing the scenes of crime and his method can still be used today, although it has now been far outstripped by the progress of stereo-photogrammetry.

Because of the deficiencies of his general education, and particularly of his knowledge of mathematics, and because of his liking for experimental research, Bertillon's labours in working out his methods were far heavier than they would have been, had he been able to apply to his observations the principles and rules of statistical computation, which has made such great strides since 1875.

Bertillon made up for the gaps in his knowledge by tenacity and unremitting efforts, which finally enabled him to overcome all obstacles; the saying that 'Genius is an infinite capacity for taking pains' is pre-eminently applicable to him. This stubbornness was one of his fundamental characteristics and is reflected in his every act. It was not always without its disadvantages, however, some of them very serious, and it probably accounts for his attitude in the Dreyfus case, from the consequences of which he was to suffer for the rest of his life.

Captain Dreyfus was court-martialled in 1894 and sentenced to transportation for life and military degradation on the evidence of a document known as the 'bordereau', informing a foreign agent of the dispatch of information relating to national defence. After many ups and downs and dramatic revelations, the Supreme Court of Appeal later recognized that no charge could be substantiated against the accused and Dreyfus, after having served part of his sentence on Devil's Island, was fully rehabilitated.

At the very beginning of the case, the 'bordereau' was transmitted to Bertillon, in order that he might establish whether or not it had been written by Dreyfus; it was a question of comparing it with the handwriting of the accused by means of enlarged photographs, on which the Head of the Criminal Records Office was particularly expert. As Bertillon had stated on many occasions, he was convinced that handwriting experts could not be absolutely sure of their conclusions and that it was impossible to prove scientifically that a particular document had been written by a given person. This makes it all the more difficult to understand why he should have agreed to give an expert opinion on the 'bordereau', and, above all, how he could have attributed it to Dreyfus.

Bertillon's advice on the 'bordereau' was sought by the Ministry of War at a time when the case was still top secret; this appeal to his patriotism was

impossible to withstand. After studying the document, Bertillon realized that it was a forgery. And indeed, if there is one thing certain in the whole case, it is that the famous 'bordereau' was not written by Dreyfus.

When he had applied his new techniques for the measurement of handwriting to the text, Bertillon in fact came to the conclusion that the writing had been traced. Not stopping there, however, he sought to show, by specious reasoning, that the tracing had been done by Dreyfus himself, in an attempt to disguise his writing. The closeness of his reasoning, although in fact deceptive, seemed to him so unquestionable that it entirely convinced him. Subsequently, even when it was obvious that he had made a mistake, his obstinacy prevented him from admitting it.

Again, Bertillon's obstinacy was at the root of his incredible distrust of fingerprints, which continued, unabated, until his death.

When the evolution of the problem of identification is viewed in perspective —the controversies and disputes in which the inventors of our methods of identifying criminals felt obliged to engage being things of the past—Bertillon's total lack of understanding of the admirable method of identification by means of fingerprints is quite astounding. As he wrote on several occasions, he was convinced that it was impossible even to begin to classify—and particularly to classify any large number of individuals—on the basis of their fingerprints. Yet, exactly the opposite is true—Bertillon's system of anthropometry cannot be used, without great complications, for large-scale classification and, as the scope of his classifications grew wider, he was obliged to resort to fingerprints as a basis for subdivisions.

His attitude is surprising—for those who created the fingerprint system and particularly Sir Francis Galton, who has the distinction of having been the first to tackle this problem as a whole and from every angle, had drawn Bertillon's attention to the possible importance of fingerprints as a morphological feature in the identification of individuals. As early as 1886 and 1888, Faulds had suggested that Scotland Yard might use fingerprints for that purpose. Nor could Bertillon have been unaware of Feorgeot's doctor's thesis on this subject, defended at Lyons in 1891 with Lacassagne, one of Bertillon's closest and most loyal friends, presiding.

Bertillon's strong dislike of the fingerprint system can therefore be explained only by his pride as an inventor, which led him to take any attempt to improve the art of identifying criminals as a personal affront.

This would account for his behaviour in 1913 towards Vucetich, the great South American fingerprint expert, who was responsible for the substitution of fingerprints for Bertillon's system of anthropometry in the South American republics. Bertillon's wounded vanity, coupled with his natural bluntness, led him into grave discourtesy towards Vucetich when, with a few biting remarks, he closed his door in the face of the visitor who had journeyed so far to see him.

Yet even today many people regard Bertillon as the 'inventor' of fingerprints. What is even more astonishing is that he, who did not believe in fingerprints, in 1902 had the honour of being the first to identify a criminal who was entirely unknown to the police except by the marks of his fingers on the glass of a piece of furniture which had been broken open after a murder. With the help of those marks, Bertillon reconstructed the murderer's fingerprints and then, with infinite patience, worked systematically through his cards, on which, as the reader will remember, fingerprints served merely as a basis for subdivisions; he finally discovered a previous offender, H. L. Scheffer, whose fingerprints were identical with those left on the scene of the crime. Scheffer, who had fled to Marseilles, was arrested, confessed, and died shortly afterwards in prison.

Bertillon undoubtedly invented the art of criminal identification, introducing into police methods the techniques and reasoning of a real science, namely, anthropology. In this sense, he may be considered as a pioneer. But is it justifiable to call him, as H. T. F. Rhodes does, the father of scientific detection?

It would be ridiculous indeed to claim that, before Bertillon, no one had thought of collecting and interpreting the material evidence left by criminals, often involuntarily, on the scene of their crimes. The search for objective evidence is as old as the world, and its development, or rather the importance attributed to it, varies according to the legal system of each country. In legal systems in which the accusatory procedure is generally adopted, primary importance has always been attached to proof by evidence. Thus in Rome, towards the end of the Republic, the *signa,* or material evidence, and the *argumenta,* or evidence of reasoning, were the basis of any accusation. Under the Empire, and with the trend towards inquisitorial procedure, the system of legal proof called for a confession, obtained if necessary by torture, or with the help of witnesses. Subsequently, up to the Middle Ages, proof of guilt was based on divine intervention in human justice, leading to trial by ordeal and the judgement of God.

When inquisitorial procedure was finally established and regulated in France by the Ordinance of 1670, the system of trying to obtain a confession took precedence over that of seeking evidence. With the Renaissance, however, scientific progress inevitably led to the adoption of more scientific methods in the investigation of evidence and the handling of proof. Though ordeals may have been called the 'expert medico-legal appraisements of the past', the progress of medicine subsequently had a very great influence on police investigations; and in this way forensic medicine, the first science to serve the cause of justice, came into being.

This happened, not only with medicine, but also with toxicology, and later with the more modern techniques evolved in the second half of the nineteenth century. Long before Bertillon's time, people had thought of

making a plan of the scene of the crime, and then of photographing it, but the process was still too complicated to form part of a policeman's everyday duties. It was not until the introduction of more and more sensitive silver bromide papers and plates that photography became a common art in general use.

It is nevertheless to Bertillon's credit that he realized how greatly this science could contribute to the improvement of police methods. While he was working out his system of identification, he also set up his photographic laboratory, originally intended for the photographing of prisoners, but later adapted to the study of fingerprints and clues left by criminals. In this sense, the excellence of his results and their general applicability fully entitle him to be known as a great pioneer in his field.

Similarly, although long before Bertillon, others had thought of collecting material evidence left on the scene of a crime and studying it in a laboratory, it appears that no one, before him, had had the idea of setting up a special body for this purpose. Such material evidence was nearly always within the field of forensic medicine, and the official pathologists often did not know enough chemistry and physics to bring those sciences to bear upon the investigation and study of clues.

In point of fact, Bertillon did not possess the necessary knowledge either, and so he concentrated on photography. This, however, covers so wide a field that the work done by Bertillon really represented the establishment of a full-scale laboratory for scientific detection. It was some time later, just before and during the first world war, that the most delicate techniques of physics and chemistry were adapted to criminal investigation problems. In this field, as in many others, the needs of national defence called for research in entirely new directions, and instruments and methods used in physics and chemistry were introduced into police laboratories, which had previously been purely photographic.

If Bertillon has a claim to be a pioneer it is not so much because he created an entirely new science of criminal investigation, as because he brought to the police, which had previously worked on a purely empirical basis, the attitude and methods of the experimental scientist. His originality lay in approaching police problems as matters for scientific research and in using the most rational methods for solving them; when he had elaborated those methods, he incorporated them in a series of specific rules, whereby the desired result was certain to be achieved.

After solving the problem of the identification of old offenders, he endeavoured, by reference to the data recorded on anthropometric cards, to devise a method of recognizing and identifying in the street an individual wanted by the police; this was the origin of anthropometric photography and the police description.

Contrary to general belief, it is impossible to identify an individual with absolute certainty from a photograph alone. There is the danger of glaring, and sometimes tragic, errors; there have been well-known cases of individuals arrested and imprisoned on account of their astonishing resemblance to certain criminals wanted by the police. The usual identity card and passport photographs, in particular, are quite unreliable, in view of the conditions in which they are taken—and especially as, in order to flatter the customer, they are often extensively touched up.

Is a photograph therefore entirely useless when looking for a suspect in the street? It certainly is, if it is taken without observing certain special rules. But on the other hand, if a portrait reveals the specific characteristics of the face, the photograph is then truly descriptive and can serve its purpose.

In fact, in such a case, the photograph is not really of great importance; it is enough to note down the facial characteristics, either from the photograph or direct from the person concerned, and to arrange them in accordance with a definite code, to be able to pick out in a crowd the person—the one and only person—who is being sought and who corresponds to the written description.

These facial characteristics, arranged in a given order, make up the *portrait parlé* (visual identification). This was probably Bertillon's most important discovery and one which has stood the test of time. The system of visual identification is still taught in most police forces in the world; it is practically irreplaceable and all attempts to substitute other methods for it have been in vain. Scarcely anything is left of the system of anthropometry, for Bertillon's photographic methods and apparatus have now been superseded by more advanced techniques; but visual identification is still, and will continue to be, what it was when invented by the genius of Bertillon.

Bertillon's work thus opened up a new era in criminal investigation. The impetus which he gave to accurate research on evidence and the attitude of mind which he introduced into the police force have continued to make steady progress ever since. And we may well wonder whither this evolution will lead us and how far it will influence the course of justice.

There is no doubt that the introduction of scientific methods into criminal investigation is a great step forward, and every discovery of science adds another stone to the structure which is daily growing before our eyes. The electron microscope, for example, with whose help the most infinitesimal objects can be studied, permits of identifications which would have been almost impossible in the past. Similarly, X-ray spectrography and microphotography provide the best method of identifying car paint, while the use of radio-isotopes is becoming more and more common; this not only enables the working of certain poisons, such as arsenic, to be followed in the human body and such appendages as hair, nails, etc., but also makes it possible to narrow down the age of prehistoric objects or bones.

It is unnecessary in this context to give further examples; those quoted are enough to show what great strides are being made in the field of criminal investigation; these developments are bound to have profound repercussions on the existing French legal system and penal code, the defects and shortcomings of which are day by day becoming so evident, that a thorough study of the possibility of revising them is at present being made.

The title of H. T. F. Rhodes' book is therefore well chosen. Alphonse Bertillon's scientific approach, the results which he achieved, and the influence which he has exercised on his successors, undoubtedly entitle him to be known as the father of scientific detection.

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